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Effect of Retinol on the Mutagenicity of Benzo[a]pyrene and Benzo[a]pyrene 4,5-oxide

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ABSTRACT

The mutagenicity of benzo[a]pyrene (BP) towards *Salmonella typhimurium* strain TA98 was inhibited by non-toxic levels of retinol. The mutagen was activated using liver homogenates ($9,000 \times g$ supernatant), (S9), from β -naphthoflavone-induced rats. Mutagenicity of benzo[a]pyrene 4,5-oxide (BP 4,5-oxide), a direct acting mutagen produced upon metabolic activation of BP, was also inhibited by non-toxic levels of retinol. The presence and absence of an S9 activating system has a significant influence on the cytotoxic effect of retinol as assayed on nutrient agar plates.

Key words: Benzo[a]pyrene mutagenicity; Benzo[a]pyrene 4,5-oxide mutagenicity; Retinol; Vitamin A; Retinoids.

INTRODUCTION

"Vitamin A" is a generic term that designates any compounds possessing the biological activity of retinol, while the term "retinoids" includes both naturally occurring forms of vitamin A and the many synthetic analogs of retinol (IUPAC-IUB, 1981). All-trans retinol, the parent retinoid compound, is a primary alcohol with a molecular weight of 286. Considerable evidence demonstrates that vitamin A and its derivatives (the retinoids) may be effective in the treatment of a variety of human diseases, including cancer (Sporn et al., 1994; Bertram et al., 1991). Retinoid deficiency has been associated with increased susceptibility to chemical carcinogenesis in certain tissues (Slaga and DiGiovanni, 1984) and enhanced mutagenicity of several compounds (Narbonne et al., 1985; Qin and Huang, 1986; Alzieu et al., 1987). Studies using the Ames test have shown that retinol completely inhibits the mutagenicity of the carcinogen 2-fluorenamine (Baird and Birnbaum, 1979) and that vitamin A (retinol and some retinyl esters) inhibits the mutagenicities of a number of precarcinogens, e.g., aflatoxin B₁ (Busk and Ahlborg, 1980) and pyrolylate products (Busk et al., 1982). A strong inhibition by vitamin A palmitate of mutagenicity induced by polycyclic aromatic hydrocarbons in a human epithelial-like cell line (Rocchi et al., 1983) and by retinol and retinoic acid of 7,12-dimethylbenz[a]anthracene-induced cytotoxicity and mutagenicity in mammalian cells *in vitro* (Budroe et al., 1988) has also been demonstrated. The mechanism by which retinoids are able to elicit these diverse and complex effects ultimately resides in their ability to regulate gene expression at specific target sites within the body. Over the past ten years a number of developments in research

have helped in elucidating the link between vitamin A action and gene control. By the mid 1980's, an abundance of evidence had led researchers to believe that almost all of these effects were due to the metabolite retinoic acid and, more specifically all-trans retinoic acid. Vitamin A (retinol) is acquired from the diet and may be interconverted between its storage form in the liver or retinaldehyde. Retinaldehyde is not only required for the visual process but also serves as the precursor to all-trans retinoic acid through an irreversible reaction. Until recently, all-trans retinoic acid was thought to be responsible for all the effects of vitamin A seen in morphogenesis, growth, and development. This view has changed dramatically with the discovery of at least two classes of retinoid receptors (Mangelsdorf, 1994). As part of our efforts to investigate the mechanism by which some compounds inhibit the mutagenicity of benzo[a]pyrene (BP) [50-32-8] (Calle et al., 1978; Sullivan et al., 1980; Calle and Sullivan, 1982), the *Salmonella typhimurium* reversion test was used in this study to investigate the effectiveness of retinol (vitamin A alcohol) [68-26-8] as an inhibitor of the mutagenicities of BP, a carcinogenic polycyclic hydrocarbon which must be activated to exert its effect (Grover and Sims, 1968; Gelboin, 1969), and of BP 4,5-oxide (4,5-epoxide) [37574-47-3] a direct acting mutagen produced upon metabolic activation of BP.

MATERIALS AND METHODS

Retinol (synthetic all-trans, type X) was obtained from Sigma Chemical Co., St. Louis, Missouri. BP (99 + % purity), and β -naphthoflavone were obtained from Aldrich Chemical Co., Milwaukee, Wisconsin. BP 4,5-oxide was provided by IIT Research Institute, Chicago, Illinois. All samples were used without further purification.

The mutagenicities of BP and BP 4,5-oxide were determined in *Salmonella typhimurium* TA98 using the method described by Ames et al. (1975) with some slight modifications previously reported (Kittle et al., 1981). To 4.5 mL of molten agar maintained at 45°C, the following ingredients were added: 15 μ L of a BP solution (4.0×10^{-4} M) or BP 4,5-oxide solution (1.7×10^{-4} M) in dimethyl sulfoxide, (DMSO), (the concentrations used were optimized previously by separate mutagenesis studies); 50 μ L of a freshly prepared solution of retinol in DMSO; the amounts of retinol per plate ranged from equimolar (6.0 nmoles/plate for the BP containing plates and 2.6 nmoles/plate for the BP 4,5 oxide containing plates) to fifty times the amounts of hydrocarbon used per plate; 0.1 mL of the overnight culture of strain TA98 of *Salmonella typhimurium* (kindly supplied by Dr. B. Ames), and 0.5 mL of potassium phosphate buffer (0.2M, pH 7.4). The system used for the activation of BP consisted of 30 μ L of the S9 fraction of a liver homogenate (protein ca. 38 mg/mL) prepared from β -naphthoflavone-induced male Sprague-Dawley albino rats weighing 260-300 g (Nebert et al., 1973), and 2.6 (moles NADPH. Toxicity tests were performed under the same conditions as the mutagenicity assay by plating 50 μ L of an overnight culture, geometrically diluted by a factor of 10^{-4} with sterile 0.9% NaCl, on nutrient agar plates. All experiments were performed at least three times, and all determinations represent the average number of colonies found on five plates. The figures and table show data from a representative experiment.

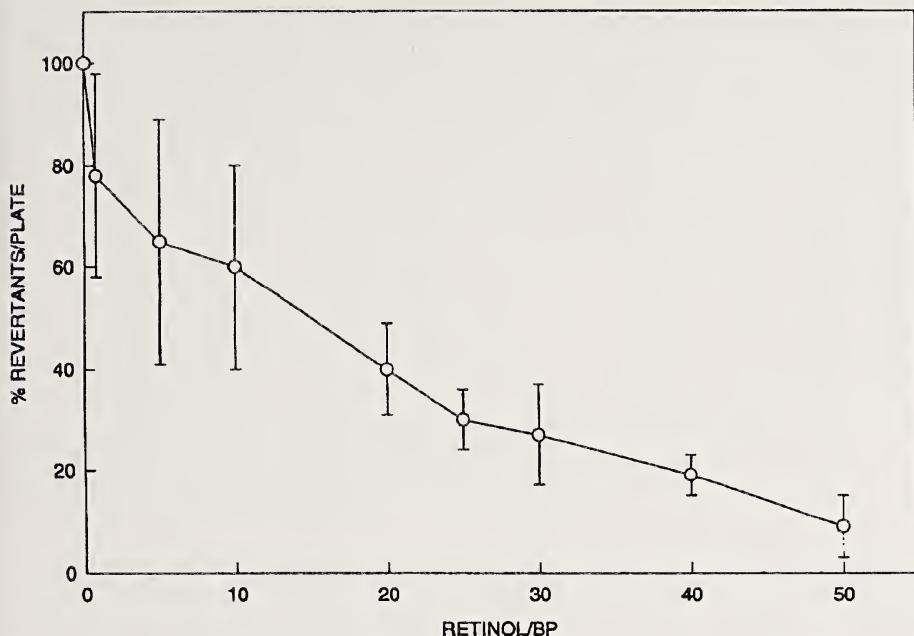


FIGURE 1. Inhibition of BP induced mutagenesis in *Salmonella typhimurium* strain TA98 by retinol. The amount of BP was kept constant at 6.0 nmoles/plate. Retinol was added in the range of 6.0 to 300 nmoles/plate. % Revertants/plate was calculated as the percentage change in the number of revertants as compared with the control value of BP revertants without retinol. A typical number of revertants in the control was 552 ± 63 colony forming units. Retinol/BP is the ratio of the concentrations of retinol and BP per plate. Error bars represent standard deviations from five replicate plates.

RESULTS AND DISCUSSION

The mutagenicity of BP towards *Salmonella typhimurium* strain TA98 was significantly decreased by the incorporation of retinol into the plates (Fig. 1). An increase in the amount of retinol, from equimolar up to fifty times the amount of the carcinogen per plate, resulted in the gradual increase of the inhibition of mutagenicity. At an amount of 86 μ g/plate, the maximum amount of retinol added per plate, the mutagenicity of BP was completely inhibited.

Similar results were obtained when retinol was incorporated into the BP 4,5-oxide containing plates (Fig. 2). BP 4,5-oxide does not require activation for mutagenicity and therefore phosphate buffer was added to the plates instead of the S9 mix. Addition of amounts of retinol equimolar to the BP 4,5-oxide in this case produced a larger decrease in the mutagenicity than that observed under similar conditions for BP. After the initial drop in the number of his⁺ revertants in the presence of equimolar amounts of retinol, the addition of retinol up to fifty times the amount of the mutagen per plate did not result in further significant decreases in the number of his⁺ revertants per plate.

The incorporation of retinol into the plates in the absence of either mutagen had no appreciable effect on the spontaneous reversion frequency. In order to further confirm that the inhibitory effect of retinol on the mutagenic activities of

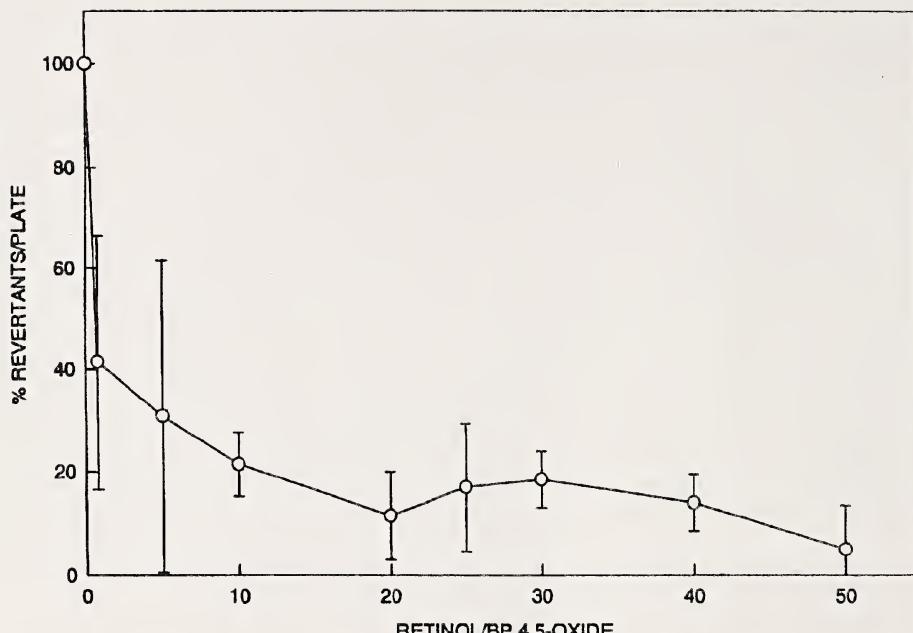


FIGURE 2. Inhibition of BP 4,5-oxide induced mutagenesis in strain TA98 by retinol. The amount of BP 4,5-oxide used was 2.6 nmoles/plate. Retinol was added in the range of 2.6 to 130 nmoles/plate. % Revertants/plate was calculated as the percentage change in the number of revertants as compared with the control value of BP 4,5-oxide revertants without retinol. Retinol/BP 4,5-oxide is the ratio of the concentrations of retinol and BP 4,5-oxide per plate. A typical number of revertants in the control is 399 ± 46 colony forming units. Error bars represent standard deviations from five replicate plates.

BP and BP 4,5-oxide was not an artifact, cytotoxic effects of retinol alone were investigated using nutrient agar plates. The toxicity tests for BP and BP 4,5-oxide differed in that buffer instead of S9 mix was used with the latter. When bacteria were exposed to the same amounts of retinol used in the BP experiment, an increasingly toxic effect was observed in the absence of S9. However, when S9 was incorporated into the system (Table 1), the toxicity was almost completely reversed although a slight but consistent decline in the bacterial count was observed with amounts of up to 105 $\mu\text{g}/\text{plate}$ of retinol. This reversal of toxicity by the S9 fraction could be due to a transformation of the retinol to a non-toxic derivative or to an S9 binding effect. Nevertheless, the toxic effect of retinol, as assayed on nutrient agar plates, is clearly distinguishable from the observed inhibitory effect on the mutagenicity of BP.

BP 4,5-oxide does not require activation by the S9 fraction and therefore the inhibition of mutagenicity in this system at concentrations of retinol larger than approximately 3 $\mu\text{g}/\text{plate}$ may be an artifact caused by killing of the bacteria by retinol (Table 1). However, the inhibitory effect of retinol on the mutagenicity of BP 4,5-oxide caused by lower concentrations of retinol (<3 $\mu\text{g}/\text{plate}$) is approximately four times larger than the inhibitory effect observed for the same amount of retinol on the mutagenicity of BP.

TABLE 1. Viability of *Salmonella typhimurium* strain TA98 on nutrient agar plates in the presence of retinol.

Retinol ^a , μg plate	Bacterial ^b viability, %	Bacterial ^c viability, %
None	100	100
2	92 \pm 8	93 \pm 10
11	62 \pm 3	99 \pm 11
21	44 \pm 5	98 \pm 13
42	39 \pm 3	82 \pm 8
53	27 \pm 1	84 \pm 8
63	18 \pm 6	80 \pm 13
84	23 \pm 2	79 \pm 14
105	21 \pm 7	64 \pm 6

a Retinol was added to the surface of the agar in 50 μL DMSO.

b Buffer instead of S9 mix was added to the surface of the agar.

c S9 was added to the surface of the agar.

The fact that the presence or absence of S9 affected the toxicity of retinol towards the bacteria (Table 1) points out the importance of examining bacterial viability in mutagenicity assays using the Ames test. Routine examination of the background lawn of bacterial growth, resulting from the trace of histidine added to the agar surface (Ames et al., 1975), as the only aid in determining the toxic effects, may not reveal the toxic effects that are observed by culturing the bacteria on nutrient agar plates in the presence of the suspect cytotoxic substance. During the course of this investigation, it was also noticed that the toxic effects observed on nutrient agar plates were more pronounced as the master plates, from which the overnight cultures were grown, aged.

The facts that non-toxic concentrations of retinol inhibit the mutagenicities of BP and BP 4,5-oxide, and that retinol toxicity is affected by the metabolizing system, suggest that retinol can alter carcinogen/mutagen metabolism. Retinol might directly interfere with carcinogen/mutagen metabolism either by inhibition of a common rate-limiting step or by altering specific pathways. Support for this hypothesis comes from the observation that retinoids can inhibit the *in vitro* microsomal oxidation of a number of compounds including carcinogens (Hill and Shih, 1974; Colby et al., 1975; Genta et al., 1974). Indirect evidence for the possible modulation of carcinogen/mutagen activating enzymes by retinyl acetate is also presented by the observations of Genta et al. (1974). Another possible explanation that can be based on the observed inhibition of mutagenicity of BP 4,5-oxide by non-toxic concentrations of retinol, is that retinol inhibits the binding to target macromolecules. If binding is predominantly a function of metabolic activation of the hydrocarbon, it is possible that this mechanism may also account, in part, for the inhibitory effect of retinol on the mutagenicity of BP. Supporting evidence for the above suggestion comes from studies with β -retinyl acetate (Yuspa et al., 1977) which showed that this retinoid can markedly alter carcinogen metabolism and binding of activated products to macromolecules. Baird and Birnbaum (1979) reported that retinol inhibits the mutagenicity of the carcinogen 2-fluorenamine,

which requires activation, thus supporting our results with BP. However, they observed no inhibition by retinol on the mutagenicity of the direct acting mutagen adriamycin in contrast to our observations with BP 4,5-oxide. This suggests that the mechanism by which retinol inhibits mutagenicity may differ for different compounds.

The results of our studies to date suggest the usefulness of the Ames test in investigating the mechanism by which retinoids exhibit anticancer and/or antimutagenic activity.

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Frassy Substrates as Oviposition/Breeding Sites for Drosophilids

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ABSTRACT

Over one thousand five hundred drosophilids have emerged from frassy fruit and nut substrates in Michigan and the mid-South (53 *D. affinis* group, 44 *D. busckii*, 38 *D. immigrans*, 554 *D. melanogaster* and *D. simulans*, 862 *Chymomyza amoena*, 5 *Scaptomyza adusta*). Both cosmopolitan and endemic species can use this niche for oviposition. Frass-breeding constitutes a fifth oviposition/larval developmental site category for temperate zone drosophilids. The evidence indicates that this may be an old niche for *C. amoena* but may be a recently invaded one for other *Drosophila*.

INTRODUCTION

Carson (1971) identified four major types of breeding sites for temperate zone drosophilids: a) fallen fruits, b) decaying bark, leaves and stems, c) slime fluxes, d) fleshy fruits. Cosmopolitan and endemic species were included in the survey. Larvae are consumers of yeast, bacteria and moulds (review: Begon, 1982). Fruits refer to typical orchard and garden fruits. Shorrocks (1982) surveyed breeding sites for temperate woodland *Drosophila* in Europe, North America and Japan. Species breeding in fermented fruits included decaying nuts, slime fluxes, decaying vegetation and fungi were listed. Intensive study of *Sorbus* berries showed flies oviposited on rotting or semirotting fruits. Use of fresh damaged berries was minimal: 3.5 flies emerging per 100 ripe berries compared to 115.3 flies emerging per 100 rotting berries. Burla and Bächli (1993) likewise bred more *Drosophila* from rotting Cornelian cherries *Cornus mas* than ripe cherries in Switzerland.

Scaptomyza are leaf miners (Carson, 1971; Collinge and Loude, 1988). *Chymomyza* larvae typically have been found under bark (Spieth, 1957; Teskey, 1976; Enomoto, 1981; Band, 1993a, 1994a; Burla, 1995).

Steyskal (1949) collected *C. amoena*, *Drosophila algonquin* and *D. paramelanica* adults on black locust (*Robinia pseudoacacia*) in Michigan; the drosophilids were feeding at fermenting frass protruding from holes in the living tree, most of which had been bored by the cerambycid beetle *Megacyllene robiniae*. Frass is insect excreta. Steyskal did not report egg deposition, however Taylor (1928) bred *C. amoena*, *D. funebris*, and *Scaptomyza graminum* from weeviled pine shoots in Massachusetts. Heed (1968) reported that one *Scaptomyza* species and three *Drosophila* species emerged from frassy substrates in Hawaii. Lachaise (1977) found that fig-breeding *Lissoccephala* females oviposited around the holes made by *Pyralidae* caterpillars or fig weevil larvae, if available. Band (1988a,b,c,d) found that *C. amoena* oviposited in curculio scars or holes and frass from codling moth larvae in parasitized fruits.

Carson (1971, 1974) also noted that some drosophilids become obligate com-

mensals and in 1974 elaborated on 3 examples of drosophilids (2 *Drosophila*, 1 *Lissocephala*) living in association with land crabs, whose larvae occupy the nephritic grooves during all or part of their prepupal development. One species (*D. carcinophila*) belongs to the *mercatorum* subgroup of the *repleta* group, another (*D. endobranchia*) belongs to the *virilis* or *quinaria* group of the subgenus *Drosophila* and therefore each descends from a different lineage in the subgenus *Drosophila*.

Carson (1971) noted that some *Drosophila* were generalists, that is able to exploit a wide variety of substrates for breeding, while the examples of parallel drosophilid evolution as obligate commensals with land crabs in 3 separate phyletic lines suggested a widespread latent genetic capacity for evolutionary innovation (Carson, 1974). Parsons and Stanley (1981) included *D. repleta*, *D. virilis* and *D. mercatorum* among the cosmopolitan and geographically widespread *Drosophila* which are also ecologically versatile. Besides *repleta* and *virilis*, other cosmopolitan species include *melanogaster*, *simulans*, *hydei*, *funebris*, *busckii*, *im-migrans*, and *annassee*. Wallace (1978) was able to adapt a *D. virilis* strain to a high urea environment. Schatzmann (1977) recorded over a thousand *D. busckii* emerging from English walnuts in Switzerland. Schatzmann commented that English walnuts were a firm substrate, but noted that Sturtevant (1921) reported that Shannon bred this species from butternut hulls. The only other species Sturtevant reported from nut hulls was *C. amoena*.

Spieth (1987) found that *Drosophila* in California could breed in parasitized acorns. Burla and Bächli (1991, 1992) bred *Chymomyza amoena*, *Drosophila subobscura* and *D. kuntzei* in Switzerland from parasitized nuts (chestnuts and acorns). The documented emergence of *C. amoena* and other drosophilids from frassy fruit and nut substrates in Michigan and in the mid-South (Band, 1985, 1986a, b, 1988a, b, c, d, 1991) indicates that frassy parasitized substrates constitute a fifth breeding site category for North Temperate zone drosophilids. Frassy fruits are not a recent niche for *C. amoena* (Band, 1994b).

MATERIALS AND METHODS

Emergence of North American drosophilids from frassy substrates has been compiled from published records (Tables 1 and 2): Heed (1968), Band (1985, 1986a, b, 1988a, b, c, d, 1991), Spieth (1987).

Flies emerging from collections recorded as frassy in Michigan and mid-South data have been enumerated. Records from Michigan substrates are from unripe parasitized fruits in June and July, from parasitized pears *Pyrus communis*, Bartlett variety in 1985 and ornamental crabapples *Malus pyramidalis* in early autumn, 1982 and 1985. Flies emerging from black walnut husks *Juglans nigra* in autumn and winter are also given. Flies emerging from pears in autumn 1987 and apples *Malus pumilla* in autumn not scored as frassy have been excluded. Records from Eden, North Carolina are from fallen unripe apples, Delicious variety, in June and July, 1984. Records from Virginia collections in 1985 and 1986 are from multiple locations and include apples, varieties unknown, in various stages of ripeness; all retained had been parasitized from their frassy condition, from emergence of pests when apples were held long enough, and/or from dissections to score for the presence of frass (Band, 1988a). Collections in Virginia in 1987 were to obtain

TABLE 1. Year of study, location, substrate, species emerging and reference for frass breeding drosophilids in Hawaii, California and Michigan; m = male, f = female.

Year	Location	Substrate	Species emerging	no.	Source
1934	Hawaii	<i>Charpentiera</i> , Apr.	<i>S. crytoloa</i>	1	Heed (1968)
1963	Hawaii	<i>Freycinetia</i> , Dec.	<i>D. crucigera</i>	1	Heed (1968)
1963	Hawaii	<i>Freycinetia</i> , Sept.	<i>D. punalua</i>	6	Heed (1968)
1963	Hawaii	<i>Freycinetia</i> , Dec.	<i>D. simulans</i>	2	Heed (1968)
1983	California	acorns, Feb., Mar.	<i>D. obscura</i> sp.	32	Spieth (1987)
			<i>D. immigrans</i>	12	
	Michigan				
1981	Lansing	apples, July	<i>C. amoena</i>	58	Band (1988a)
1982	E. Lansing	apples, July	<i>D. melanogaster</i>	4	Band&Band
			<i>D. affinis</i>	6	(1983)
			<i>C. amoena</i>	25	
1985	Lansing	apples, Oct.	<i>D. melanogaster</i>	2m	Band (1986a,b)
			<i>D. simulans</i>	7m	
			<i>D. mel. +D. sim.</i>	8f	
			<i>D. immigrans</i>	3	
			<i>C. amoena</i>	1	
1987	E. Lansing	apples, July	<i>C. amoena</i>	130	
1991	E. Lansing,	apples, June	<i>C. amoena</i>	15	unpublished
1992	E. Lansing	apples, June	<i>C. amoena</i>	6	unpublished
1985	E. Lansing	pears, Sept.	<i>D. melanogaster</i>	194m	Band (1986b)
			<i>D. simulans</i>	1m	
			<i>D. mel. +D. sim.</i>	270f	
			<i>D. immigrans</i>	4	
1982	E. Lansing	ornamental crabapples, Oct.	<i>D. melanogaster</i>	5m	Band&Band
			<i>D. simulans</i>	3m	(1983)
			<i>D. mel. +D. sim.</i>	13f	
			<i>C. amoena</i>	5	
1985	E. Lansing	ornamental crabapples, Oct.	<i>D. melanogaster</i>	4m	Band (1986b)
			<i>D. simulans</i>	3m	
			<i>D. mel. +D. sim.</i>	21f	
			<i>C. amoena</i>	1	
1983	Lansing	blackwalnuts, Jan.,Nov	<i>C. amoena</i>	29	Band (1988a)
1984	Wmstown	blackwalnuts, Nov.	<i>C. amoena</i>	125	Band (1988a)
1985	Lansing	blackwalnuts, Oct.	<i>D. busckii</i>	4	Band (1986a)
			<i>D. immigrans</i>	3	
			<i>C. amoena</i>	2	
1987	E. Lansing	plums, June	<i>C. amoena</i>	25	Band (1988a)
1989	E. Lansing	plums, June	<i>S. adusta</i>	2	unpublished
			<i>C. amoena</i>	1	
1992	E. Lansing	plums, June	<i>D. affinis</i> gr.	1f	unpublished
			<i>S. adusta</i>	1	
			<i>C. amoena</i>	22	

TABLE 2. Year of study, location, substrate, drosophilid species emerging and reference for mid-south collections in the 1980s and 1990s; m = male, f = female.

Year	Location	Substrate	Species emerging	no.	Source
1984	Eden, N. C.	apples, June and July	<i>D. affinis</i>	3	Band (1985)
			<i>D. melanogaster</i>	4	
			<i>D. busckii</i>	40	
			<i>D. immigrans</i>	1	
			<i>C. amoena</i>	22	
			<i>S. adusta</i>	2	
1985	Rt. 700, VA	apples, July and August	<i>D. affinis</i>	35	Band (1988a)
			<i>D. melanogaster</i>	6	
			<i>D. immigrans</i>	14	
			<i>C. amoena</i>	48	
1986	Danville, VA	apples, June	<i>D. affinis</i> sp.	6	Band (1988c)
			<i>D. quinaria</i> sp.	1	
			<i>C. amoena</i>	68	
			diastatids	3	
1986	Blacksburg, VA	apples, July	<i>C. amoena</i>	15	Band (1988a)
1986	Rt. 700, VA	apples, June	<i>C. amoena</i>	36	Band (1988a)
1990	Blacksburg, VA	apples, July	<i>C. amoena</i>	15	unpublished
	Rt. 700, VA	apples, July	<i>D. immigrans</i>	4	unpublished
			<i>C. amoena</i>	38	
			<i>Drosophila</i> sp.	7	
	Pamplin	apples, July	<i>C. amoena</i>	23	unpublished
1991	Pamplin	apples, July	<i>D. immigrans</i>	4m	unpublished
			<i>D. immigrans</i>	5f	
			<i>D. melanogaster</i>	1m	
			<i>D. melanogaster</i>	4f	
			<i>C. amoena</i>	9	
	Danville,	apples, July	<i>D. robusta</i>	20f, 15m	unpubl.
	Blacksburg	apples, July	<i>C. amoena</i>	2	
	Rt. 700	apples, July	<i>D. affinis</i>	2	
			<i>C. amoena</i>	4+	
1992	Rt. 700	apples, July	<i>C. amoena</i>	14	unpublished
1989	MLBS, VA	acorns, July	<i>C. amoena</i>	74	Band (1991)
1989	MLBS, VA	acorns, Sept.	<i>D. melanogaster</i>	4	Band (1991)
			<i>C. amoena</i>	7	
1990	MLBS, VA	acorns, July	<i>C. amoena</i>	41	unpublished
1992	Rt. 700	oriental chestnuts, October	<i>C. amoena</i>	1	Band (1993b)

further data on aggregated oviposition (Band, 1988c, 1989); the condition of the individual apples was not recorded. In general, drosophilids emerge before any true pests: lesser apple worm *Grapholitha prunivora*, apple maggot *Rhagoletis pomonella*, codling moth *Cydia pomonella* and plum curculio *Conotrachelus nenuphar*.

Emergence of *C. amoena* from damaged acorns collected at Mt. Lake Biologi-

cal Station was documented in summer and fall 1989 (Band, 1991). Acorns were again collected in July 1990; parasitized acorns were scored for the presence of eggs and larvae, and then held for adult emergence. This was done to verify that only *C. amoena* breeds in acorns despite the presence of other *Chymomyza* in the forest (Band, 1988d, 1993a, 1994a, 1995a, b). In October 1992 old oriental chestnuts (*Castanea mollissima*) that showed evidence of prior parasitism were collected at the Rt. 700 site near Mt. Lake. Newly fallen nuts from which pest larvae had not emerged were also collected (Band, 1993b).

The problem of sibling species: Sibling species occur among drosophilids and require additional tests for accuracy of identification. *Drosophila pseudoobscura* and *D. persimilis* emerging from acorns in California were not differentiated electrophoretically (Spieth, 1987). Males of *D. melanogaster* and *D. simulans* can be distinguished by their genitalia. However, progeny from *D. melanogaster* and *D. simulans* females were not grown to determine the genitalia of F₁ males. Males of the *D. affinis* group can be differentiated by sex combs. When only females emerged no species was assigned.

Microbial studies: The intestinal contents of *C. amoena* larvae were plated in December 1982 to determine they had continued feeding in a mild winter (Band and Band, 1984). Frass was plated from unripe green frassy apples with and without *C. amoena* larvae the following summer. Media used were nutrient agar and yeast-extract-Proteous Peptone (Difco)-glucose containing medium.

RESULTS

Table 1 lists the year, location, substrate, month collected, drosophilid species emerging and numbers of each species recorded from Hawaii, California and Michigan. Frass-breeding was specifically noted early among drosophilids in the western world, a *Scaptomyza* in 1934 in Hawaii (Heed, 1968), but implied by the emergence of drosophilids from weeviled pine shoots in Massachusetts (Taylor, 1928).

Spieth (1987) lists the *Drosophila* species emerging from acorns collected at Oakmont, California by Dr. William Marshall as *immigrans* and *obscura* group. Laboratory studies have demonstrated that *D. pseudoobscura*, *D. melanogaster*, and *D. immigrans* females will oviposit in holes made by emerging insect larvae or in the vascular elements at the base of the acorn, and adults will emerge.

In Michigan *C. amoena* was the only drosophilid to emerge from frassy fruits in early summer until 1989 when 2 *Scaptomyza adusta* also emerged from parasitized plums. The presence of other drosophilids in July can be variable. In September and October, parasitized fruits (apples, pears, ornamental crabapples) and black walnuts may serve as drosophilid breeding sites. Pears are typically parasitized by codling moth, ornamental crabapples by apple maggot larvae. The existence of numerous apple trees in suburban gardens suggests that ornamental crabapples are a late season oviposition niche for apple maggot but larvae in October are killed by the onset of winter.

The 1985 apples and black walnuts had fallen from adjacent trees in Lansing. The 1985 pears in September and ornamental crabapples in October were also in the same garden in East Lansing (Band, 1986a,b). Neither the adjacent apples and black walnuts at one site nor the pears and ornamental crabapples in the same

TABLE 3. Genus, subgenus (if established), species group and species having frass breeding members in the United States and Hawaii.

Genus	Subgenus	Species group	Species
<i>Drosophila</i>	<i>Sophophora</i>	<i>melanogaster</i> <i>obscura</i>	<i>melanogaster, simulans</i> <i>affinis, WestCoast</i> species
<i>Drosophila</i>	<i>Dorsilopha</i>	<i>busckii</i>	<i>busckii</i>
<i>Drosophila</i>	<i>Drosophila</i>	<i>immigrans</i>	<i>immigrans</i>
<i>Drosophila</i>	<i>Drosophila</i>	'picture-wing'	<i>crucidera, punalau</i>
<i>Scaptomyza</i>	<i>Trogloscaptomyza</i>		<i>cryptoloba</i>
<i>Scaptomyza</i>			<i>adusta</i>
<i>Chymomyza</i>		<i>fuscimana</i>	<i>amoena</i>

garden at the second site contain the same complement of drosophilids. *Drosophila busckii* had earlier been bred from nut husks (Sturtevant, 1921; Carson, 1965), and was the dominant *Drosophila* to emerge from English walnuts in Switzerland (Schatzmann, 1977). As shown in Table 1, *D. immigrans* in both eastern and western North America can develop in parasitized nuts, *D. simulans* in parasitized fruits.

Drosophilid larvae, mostly *C. amoena*, were found in parasitized acorns collected in 1989 both in northern lower and mid-Michigan. However there was no emergence in the laboratory (Band, 1991).

Table 2 gives the drosophilid species emerging from unripe frassy apples 1985-1986 and from later (post-1987) collections in Virginia, when notation was made about the parasitized condition of the apples. Species in frassy fruits in June may be found in frassy substrates in Michigan later in summer.

Table 2 also shows that *C. amoena* is the only *Chymomyza* to emerge from acorns. The fact that *D. melanogaster* emerged from acorns in autumn 1989 indicates that *Drosophila* in the east have the capacity to invade and develop in this substrate as observed elsewhere (Spieth, 1987, 1988; Burla and Bächli, 1992). *Chymomyza amoena* larvae were found in old parasitized oriental chestnuts and one adult emerged. Females from laboratory stocks oviposited on and in newly fallen nuts from which weevil larvae had exited (Band, 1993b).

Frass breeding by drosophilid classification: Table 3 gives the genus, subgenus and species group, if established, for the North American species which have emerged from frassy substrates. The *Drosophila* cosmopolitan species are well represented: *melanogaster, simulans, busckii, immigrans*. Two endemic species now found on other Continents, *Drosophila pseudoobscura* (Millar and Lambert, 1985) and *Chymomyza amoena* (Burla and Bächli, 1992; Máca and Bächli, 1994) can exploit the frass breeding niche. European *Drosophila subobscura*, now on the west coast of Chile and California (Ayala et al., 1989), has also been found in nuts and as well as fruits.

In Hawaii, California, Michigan and the mid-South both cosmopolitan and endemic species emerge from frassy substrates. In California, Michigan, the mid-South and Switzerland, interspecies dependency is evident in the use of exit

holes in firm substrates that drosophilid females enter to oviposit in the frassy interior (Spieth, 1987, 1988; Band, 1988a,b,c,d; Burla and Bächli, 1992).

Microbial content: *Chymomyza amoena* larvae from ornamental crabapples in winter 1982/83 contained fungi and yeast in their gut. Frass plated from unripe parasitized apples the following summer contained only bacteria. One culture also had a ciliate (Protozoa).

DISCUSSION

Firm parasitized nut and fruit substrates as oviposition sites for drosophilids only recently appear to have been investigated (Spieth, 1987, 1988; Band, 1988a,b,c,d, 1991, 1994b; Burla and Bächli, 1991, 1992). For *C. amoena* the nuts and fruits can serve as larval overwintering sites and summer season breeding sites (Band, 1988a,b,c,d; Band and Band, 1984).

Neither Throckmorton (1975) nor Ferrar (1987) listed *Chymomyza* breeding in fruits. Ferrar (1987) also states that *Drosophila* species breed only in fruit that is already damaged, fermented and unfit for human consumption and enumerated the same drosophilid feeding/breeding niches of his predecessors: decaying fruits and vegetation, slime fluxes, fungi, living flowers (Neotropics), specialized niches (cacti; crabs).

Given that instances of drosophilid frass feeding and breeding were noted in the 1920s, 1930s and 1940s (Taylor, 1928; Steyskal, 1949; Heed, 1968), we may ask if the frassy parasitized niche has become a new niche for *C. amoena* and for other *Drosophila*. *Chymomyza amoena*, *Scaptomyza adusta*, *D. affinis* in the East (Sturtevant, 1921), *D. obscura* group species in the West (Dobzhansky, 1937) are native North American species. *Drosophila melanogaster*, *D. simulans*, *D. busckii*, and *D. immigrans* are immigrants (Sturtevant, 1921), recognized now as cosmopolitan, associated with domestic habitats and readily attracted by fermenting fruits (Carson, 1971; Parsons and Stanley, 1981).

Prussian dipterist Hermann Loew in 1862 described *Chymomyza amoena* as *Drosophila amoena* from specimens collected in Washington, D. C., and described *D. melanogaster* as *D. ampelophila* from specimens collected in Cuba. By the 1870s *D. ampelophila* had invaded the U. S., and was spreading rapidly along the east coast. In 1882 J. H. Comstock found that the life cycle of *D. ampelophila* in decaying (fermenting) orchard apples averaged about 14 days compared to over a month for *D. amoena*. He called both pomace flies because of the attraction especially of *D. ampelophila* to crushed fruits or pomace as at wineries and cider mills (Band, 1994b). Although Sturtevant (1921) stated he bred *C. amoena* from apples, his mention of nut breeding and the later reports of Dowdy (1955), Winston (1956) and Dorsey *et al.* (1962) of *C. amoena* in acorns would suggest displacement to nuts due to competition. However, *C. amoena*'s tendency to oviposit in frass, in scars made by curculio weevils and holes made by codling moth (Band, 1988a,b,c,d) enabled its identification as the "Drosophila apple fly." This was a *Drosophila* found by A. S. Packard in 1869 to follow curculio and codling moth into early apples in Massachusetts, but was never identified and subsequently was forgotten (Band, 1994b). Baron Osten-Sacken had been Packard's authority that the dipteran in Massachusetts apples was a *Drosophila* and Walsh's authority that the dipteran in eastern apples and Illinois haws was apple maggot (*Trypetta pomonella* = *Rhagoletis*

pomonella). *Chymomyza amoena*'s 1869 emergence date from Massachusetts apples is earlier than the previous recorded 1891 date from Michigan apples (Band, *ibid.*).

Band (1988a,b,c) had earlier argued that *C. amoena*'s breeding in parasitized nut/fruits was likely of prehistoric vintage and the species awaited only attacking insects to enter domestic (commercial fruits). Early explorers described North America as a heavily forested land with oaks, chestnuts, walnuts, plums, grapes and other trees and shrubs (Cumming *et al.*, 1972). The colonists brought domestic plums, peaches, apples, apricots, and nectarines with them. In 1781 Jefferson listed the wild fruit and nut bearing trees native to Virginia, including crabapples (Jefferson, 1955), and noted in 1791 that weevils were attacking plums, apricots, nectarines and peaches in Philadelphia (Betts, 1944). Codling moth invaded in the late 18th/early 19th century. Winston (1956) and Dorsey *et al.* (1962) demonstrated that *C. amoena* larvae could be found in acorns as soon as exiting curculio or lepidopteran larvae made access holes enabling oviposition. No doubt, native *C. amoena* had long followed native curculio from nuts into plums and crabapples. The opportunity to follow pests into domestic (commercial) apples in Massachusetts appears to have preceded a similar opportunity in Michigan, as would be expected.

Lumme and Lakovaara (1983) have encouraged the study of northern drosophilids. As forested lands have come under cultivation, native substrates have been replaced by commercial orchards and crops. This phenomenon accelerated in the second half of the nineteenth century in states such as Michigan. In other areas, as the South, former commercial crops as tobacco, have lost their universal appeal, and replacements are needed.

Mayr (1963, see also Plotkin, 1988) argued that a shift to a new niche is usually initiated by a change in behavior. Host shifts by insects have also been argued to require a genetic change. Diether (1986) has also pointed out that different genes may control host preference, substrate suitability for larval development, and detoxification processes. Drosophila typically produce several generations during the breeding season. Monophagy is restricted to substrates which are continuously available for an extended period of time, and seems more prevalent in the Neotropics than among temperate zone drosophilids. Carson (1974) noted and Wallace (1978) demonstrated a latent capacity in drosophilids to adapt to a high urea/nitrogenous environment.

In addition to cosmopolitan *Drosophila*, which are substrate generalists and found on all continents, Parsons and Stanley (1981) recognized two other types of widespread *Drosophila*: those that are ecologically versatile and those that are ecologically restricted. The latter include *D. buzzatii* and *D. aldrichi* which breed in *Opuntia* cactus. The former include members of the *obscura* group species, *D. robusta*, and other widespread *Drosophila* that occur in domestic and natural habitats. In the east *D. affinis*, and to a lesser extent *S. adusta*, also appear to be widespread and ecologically versatile. Many species are tending to spread, as *D. pseudoobscura*, and *D. subobscura*.

Chymomyza amoena also merits inclusion in the widespread, ecologically versatile category; typical drosophilid phytophagy characterized its oviposition in nuts and wild fruits before the colonists arrived and may be a factor in its rapid spread in Europe. Larvae also appear to feed on a variety of microbes. As Winston (1956)

found, larvae are not primarily yeast feeders. This may be a general *Chymomyza* trait (Carpenter, 1954; Grimaldi, 1986).

Behavioral change appears not to have been involved for *C. amoena* to have invaded domestic fruits. As an acorn breeder, it was already classified as a secondary invader (Dorsey et al., 1962) and as a fungal feeder and scavenger (Winston, 1956). Vosso (1984) studied acorn predators and associate fungi taken from a Mississippi forest (*C. amoena* was not among them) and found *Penicillium* sp. with curculio larvae, but also obtained *Fusarium solani* and *Epicoccum purpurascens*, possibly as acorn surface contaminants. Winston (1956) found that *C. amoena* fed on both *Fusarium* and *Penicillium*. Botanists argue that *Penicillium* is not insect transmitted (Rosenberg, 1990; Cipollini and Stiles, 1993). However, if drosophilids are found to transport undesirable microbes, Ferrar's (1987) claim they are of no economic importance may have to be revised.

Drosophila busckii is the only other *Drosophila* known for many decades to be capable of breeding in nuts and nut husks (Sturtevant, 1921; Carson, 1965; Schatzmann, 1977; Shorrocks, 1982), although Malloch and McAtee (1924) also bred two cosmopolitan *Drosophila* (*funebris* and *melanogaster*) from butternut hulls. In the case of *D. busckii* from Eden, North Carolina apples, larvae could not be grown on laboratory medium. Females laid eggs, which hatched, but larvae wandered around, then died. Wallace (1978) described a similar phenomenon when the *D. virilis* strain adapted to the high urea environment was transferred back to standard *Drosophila* medium. Parsons and Hoffman (1986) demonstrated that a genetic basis for habitat preference exists in *Drosophila*. From *D. busckii*'s observed reaction, it suggests that in the natural environment sufficient frassy substrates exist throughout the breeding season to permit the evolution and persistence of a resource-dependent *D. busckii* strain.

Dorsey et al. (1962) found the chestnut curculio was invading acorns in the absence of chestnut trees in forests. *Chymomyza amoena* may have bred in chestnuts also in this country before this once dominant tree in Eastern hardwood forests succumbed to chestnut blight introduced in the early 1900s.

Invasion of frassy substrates by *Drosophila* seems recent in time compared to *C. amoena*. Fruit odor will attract *Drosophila* (Parsons and Hoffman, 1986). The replacement of lush woodlands first by farms and orchards, then by cities and suburbs with a further cutback in land area devoted to crop and fruit production may be encouraging the *Drosophila* invasion of the parasitized ripening fruit niche. Further evidence for this comes from the finding that although endemic *D. affinis* is typically trapped in early spring in Michigan (Band, 1993b), it has rarely been bred from frassy fruits in Michigan in summer in contrast to Virginia and North Carolina.

The emergence of drosophilids from frassy substrates on other Continents and islands, as Hawaii, also suggests that it is an opportunistic invasion, whose success is due to the immense amount of genetic variation existing within populations. Existing behaviors as attraction to fruit odors and aggregation tendencies (Band, 1989; Burla and Bächli, 1993) may increase a female's chances for willingness to oviposit in a ripening parasitized fruit substrate. Shorrocks et al. (1984), and Parsons and Hoffman (1986) argued however than interactions among *Drosophila* species using similar resources might be unimportant. Parasitism, microbial con-

tent, the degree of fruit ripening may serve to "structure" a pool of otherwise similar substrates. Independent association between drosophilid competitors (Shorrocks, 1990) may not exist if females of one or more species choose "parasitized" to merely damaged substrates for oviposition. Interspecific aggregation of drosophilids merits further study.

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A Comparative Study of Spruce Growth Rates in Four Different Regions of the World

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ABSTRACT

Coniferous forests in which some member of the genus *Picea* (spruce) is present as a dominant or codominant species occur throughout the Northern Hemisphere. During the period of 1985-89, quantitative data on composition and structure of the vegetation and soil chemical and physical characteristics were obtained for forest communities containing red spruce (*Picea rubens* Sarg.) in the Appalachian Mountains of central West Virginia, Engelmann spruce (*P. engelmannii* [Parry] Engelm.) in the Swan Mountains of northwestern Montana, white spruce (*P. glauca* [Moench] Voss) in central Alaska, and Himalayan spruce (*P. smithiana* [Wallich] Boiss.) in the Himalayan Mountains of northwestern India. In order first to determine and then to compare general patterns of growth and ages of the species of spruce at each study site, increment growth cores also were collected. The importance value (%) recorded for spruce ranged from 7.0 for Himalayan spruce in India to 63.1 for white spruce in Alaska. Spruce shared dominance with an admixture of eight species of hardwoods in the tree stratum at the study area in West Virginia; at the three other study areas, dominance was shared with only one or two other species. Mean number of rings \pm SE for cored trees ranged from 96 ± 6.5 to 220 ± 13.3 . Total radial growth for the period 1900-79 varied considerably (76.0 to 194.8 mm), with the highest value recorded for Himalayan spruce (youngest overall) and the lowest value for white spruce (highest latitude).

INTRODUCTION

Coniferous forests in which some member of the genus *Picea* (spruce) is present as a dominant or codominant species commonly occur at higher latitudes and higher elevations throughout the Northern Hemisphere. In eastern North America, red spruce (*Picea rubens* Sarg.) is the most characteristic species of the subalpine coniferous forests that occupy higher peaks and ridges of the Appalachians. Dendroecological (tree-ring) data from several studies (e.g., Adams et al., 1985; McLaughlin et al., 1987) recently conducted in spruce and spruce-fir forests of the Appalachians indicate that a reduction in average ring widths (radial increments) has occurred in red spruce during the past 20 to 25 years. Several hypotheses have been proposed to explain this growth-trend decline, including climatic factors (e.g., Cook et al., 1987; Cook and Johnson, 1989; Hamburg and Cogbill, 1988), disease (e.g., Mielke et al., 1986), community dynamics (e.g., Federer and Hornbeck, 1987; Hornbeck et al., 1986, Reams and Huso, 1990; Van Deusen, 1990; Zedaker et al., 1987), atmospheric pollution (McLaughlin et

al., 1987), or possible combinations of some of the preceding (e.g., Van Deusen et al., 1991). A general consensus was developed by the several authors in the last chapter of *Ecology and Decline of Red Spruce in the Eastern United States* (Eagar and Adams, 1992), concluding "... that airborne pollutant chemicals have provided the principal impetus for red spruce decline" (p. 410). However, these same authors also point out that many gaps in information still remain. One of the major difficulties associated with objectively evaluating this recent reduction in red spruce radial growth is determining whether, in fact, it does represent a substantive departure from what might be considered "normal" for spruce. Norway spruce (*Picea abies* [L.] Karst.) in western Europe has exhibited widespread decline (a general syndrome referred to as *Waldsterben*) (Shutt and Cowling, 1985), but there appear to be few data available for other species of spruce in the Northern Hemisphere for comparison of growth rates. Consequently, it would seem worthwhile to compare the recent (i.e., since 1900) growth pattern of red spruce with those of several other species of spruce found elsewhere in the Northern Hemisphere.

The primary purpose of this paper is first to describe and then to compare the general patterns of radial growth since 1900 for four different species of spruce found in widely separated regions of the Northern Hemisphere. In addition, very general quantitative data on vegetation and soils are provided for the forest communities in which these four species of spruce occur as canopy dominants or codominants.

THE STUDY AREAS

The increment growth cores and quantitative data upon which this paper is based were collected during the period of 1985-89 from four different study areas: (1) the Gaudineer Scenic Area on Cheat Mountain in central West Virginia ($38^{\circ}40'$ N latitude, $81^{\circ}30'$ W longitude), elevation 1220 m, old-growth red spruce (*Picea rubens*)-northern hardwood forest; (2) the Swan Mountains in northwestern Montana ($48^{\circ}09'$ N latitude, $114^{\circ}56'$ W longitude), elevation 2040 m, subalpine spruce (*Picea engelmannii* [Parry] Engelm.)-fir forest; (3) the Bonanza Creek Experimental Forest near Fairbanks in central Alaska ($64^{\circ}55'$ N latitude, $146^{\circ}10'$ W longitude), elevation 300 m, upland old-growth white spruce (*Picea glauca* [Moench] Voss)-quaking aspen forest; and (4) near the village of Narkanda in the Himalayan foothills of Himachal Pradesh, northwestern India ($31^{\circ}16'$ N latitude, $77^{\circ}27'$ E longitude), elevation 2700 m, montane Himalayan spruce (*Picea smithiana* [Wallich] Boiss.)-fir forest.

Geological substrata exposed at the surface on Cheat Mountain in central West Virginia are predominantly coarse sandstones and conglomerates. Annual precipitation at higher elevations in this region of West Virginia usually exceeds 150 cm and is generally well distributed throughout the year with no pronounced dry season (Core, 1966). Lower elevations within the Swan Mountains of northwestern Montana receive an average of about 75 cm of precipitation annually; although detailed climatic data are lacking, somewhat higher values would be expected for higher elevations in the same region. The winter months and June are relatively moist, but only 3-5 cm/mo occurs during July and August (McCune, 1982). The underlying geological substrata of the general study area are primarily

quartzites and argillites (Pfister et al., 1977). Average annual precipitation for the study area in central Alaska is approximately 30 cm, about 35% of which falls as snow. The bedrock consists of schist overlain by a layer of micaceous loess of varying thickness (Van Cleve et al., 1986). Total annual precipitation for Himachal Pradesh in northwestern India usually exceeds 150 cm, with the major portion (>70%) occurring during the monsoon months of July to September. The major geological formations of this region of the Himalayas consist largely of calcareous shales and limestones, with some quartzites, slates, and sandstones also present (Gansser, 1964).

METHODS

In each study area, the unit of forest vegetation (stand) selected for sampling met the following criteria: (1) typical of the general study area with respect to both general composition and floristics, (2) a relatively homogeneous unit of vegetation, (3) located in an area of essentially uniform topography, and (4) no evidence of appreciable recent (< 30 yrs) disturbance by humans or other causes. For the study areas in Montana and Alaska, quantitative data for the tree stratum were obtained from a single 20 by 50 m (0.1 ha) rectangular plot laid out with its long axis parallel to the contour of the slope; two such plots were used for the study area in West Virginia. In India, the tree stratum was sampled using the point-centered quarter method (Mueller-Dombois and Ellenberg, 1974). Species and diameter were recorded for all woody stems 10 cm DBH (diameter at breast height; 1.37 m).

Field data were converted to absolute measures. Density (number of stems per hectare) and basal area (m^2 per hectare) were determined for all species. These data were then used to calculate species importance value indices (Curtis and McIntosh, 1951). As used in this paper, importance values are one-half the sum of relative density and relative basal area.

Increment growth cores were collected from at least twelve representative larger (i.e., canopy dominants or codominants), healthy (i.e., without obvious visible damage) spruce trees in each study area. Trees selected for coring occurred both within and outside the plot or area actually sampled. Cores from the India, Alaska, and Montana localities originally were collected only for the purpose of determining the ages of the largest trees in stands, rather than for the data we are sharing in this report. Consequently, no effort was made to establish comparable conditions (e.g., obtain cores from the same number of trees) in all stands.

Cores were extracted at breast height using a standard Swedish-made increment borer. In the laboratory, cores were air-dried, mounted on grooved boards, and sanded. Cores from each region were crossdated to assure that measurements were made for comparable time periods. In order to determine the general trend of growth, total ring widths for each five-year period were measured to the nearest 0.1 mm. Measurements from all cores for a particular study area were grouped and a mean value for each five-year interval was calculated. Further, growth of each species in the present century, 1900 through 1979, was determined in twenty-year intervals in order to detect any obvious differences in growth over longer periods of time. Since no attempt was made to control age/maturity or competitive status of trees at the various sites and our data are limited, we have chosen to make only general comparisons of growth patterns among sites.

Soil samples were collected from four or more locations in each study area and brought back to the laboratory for analysis. In the laboratory, samples were oven-dried at 100° C for 48 hours and then passed through a 2-mm sieve to remove gravel. Soil pH values were determined in a 1:1 soil:water mixture with a glass electrode pH meter, organic matter was determined by loss on ignition (Cox, 1990), and soil texture was analyzed with the Bouyoucos hydrometer method (Bouyoucos, 1951). Later, analyses of phosphoric acid, calcium, magnesium, potassium, zinc, nitrate nitrogen, and total soluble salts were conducted by the Soil Testing Laboratory at Virginia Polytechnic Institute and State University, using the procedures outlined by Donohue and Friedericks (1984).

RESULTS AND DISCUSSION

Composition of the tree stratum in each of the four study areas is given in Table 1. The importance value recorded for spruce in the stands we sampled varied widely, ranging from 7.0 for Himalayan spruce in India to 63.1 for white spruce in Alaska. Spruce shared dominance with eight other species (an admixture of northern hardwoods) in the tree stratum at the study area in West Virginia; at the three other study areas, dominance was shared with only one or two other species.

The mean number of rings for cored trees ranged from 96 (India) to 220 (Montana) (Table 2). Since pith was not reached in all cored trees and stem growth to breast height occurred over innumerable years, these ages should be considered conservative estimates. Ages of spruce at the West Virginia and Montana sites were comparable and are in a range probably considered representative of mature trees for both species. In contrast, spruce at the Alaska and India study sites were younger and thus cannot be considered "mature" (even though they were canopy dominants). Maximum number of rings recorded for any one tree (368) was from a red spruce in West Virginia.

Total radial growth for the period 1900-1979 (Table 2) varied from 76.0 mm for white spruce in Alaska (presumably the site with harshest environmental conditions) to 194.8 mm for Himalayan spruce in India (on average, the youngest trees we sampled). As a general observation, subalpine spruce in Montana exhibited the most consistent growth during the past century, whereas Himalayan spruce displayed the most erratic growth. Both red and white spruce evidenced slower growth beginning in 1940. The period 1960-1979, constituting twenty-five percent of the total period of growth since 1900, is the time interval for which a considerable reduction in radial growth has been reported for red spruce throughout its range in the Appalachian Mountains of the eastern United States (Siccama et al., 1982; Johnson and Siccama, 1983; McLaughlin, 1985; Adams et al., 1985; McLaughlin et al., 1987; Adams et al., 1990). Interestingly, the data presented in Table 2 show that radial growth during the 1960-1979 interval exceeded twenty percent of the total growth since 1900 for all but red spruce in West Virginia. In fact, radial growth for each of the other twenty-year time intervals since 1900 (i.e., 1900-1919, 1920-1939, and 1940-1959) exceeded twenty percent of the total growth for all species except Himalayan spruce during the 1900-1919 time interval, when these trees presumably were growing under suppressive subcanopy conditions. Only rarely did radial growth for any of the four species of spruce in a given twenty-year time interval exceed thirty percent of the total growth since 1900. The highest value was recorded

TABLE 1. Composition of the tree stratum (stems ≥ 10 cm DBH) for each of the four study areas. Nomenclature follows Radford et al. (1968) for West Virginia, Hitchcock and Cronquist (1973) for northwestern Montana, Hultén (1968) for Alaska, and Polunin and Stainton (1984) for northwestern India.

Species	Density (N/ha)	Relative density (%)	Basal area (m ² /ha)	Relative Basal area (%)	Importance value
WEST VIRGINIA					
<i>Picea rubens</i>	140	30.8	17.29	45.8	38.3
<i>Betula lutea</i>	115	25.3	7.13	18.9	22.1
<i>Fagus grandifolia</i>	100	22.0	5.09	13.5	17.7
<i>Prunus serotina</i>	15	3.3	4.19	11.1	7.2
<i>Acer rubrum</i>	20	4.4	3.02	8.0	6.2
<i>Acer pensylvanicum</i>	30	6.6	0.32	0.9	3.7
<i>Magnolia acuminata</i>	15	3.3	0.48	1.3	2.3
<i>Magnolia fraseri</i>	15	3.3	0.20	0.5	1.9
<i>Liriodendron tulipifera</i>	5	1.1	0.01	0.1	0.6
Total	455	100.0	37.73	100.0	100.0
NORTHWESTERN MONTANA					
<i>Abies lasiocarpa</i>	910	96.8	25.83	79.1	87.9
<i>Picea engelmannii</i>	30	3.2	6.83	20.9	12.1
Total	940	100.0	32.66	100.0	100.0
CENTRAL ALASKA					
<i>Picea glauca</i>	620	58.5	30.19	67.6	63.1
<i>Populus tremuloides</i>	320	30.2	11.46	25.7	27.9
<i>Betula papyrifera</i>	120	11.3	3.01	6.7	9.0
Total	1060	100.0	44.66	100.0	100.0
NORTHWESTERN INDIA					
<i>Abies pindrow</i>	282	92.5	75.34	93.6	93.0
<i>Picea smithiana</i>	23	7.5	5.18	6.4	7.0
<i>Taxus baccata</i>	—	—	—	—	P*
Total	305	100.0	80.52	100.0	100.0

*not encountered during sampling but present in the general study area

for red spruce during the 1920-1939 time interval when 31.8 percent of its total radial growth between 1900 and 1979 occurred.

Inspection of the radial increment patterns (based on five-year means) presented in Figure 1 reveals that growth of both Himalayan spruce and red spruce increased rapidly in the early 1900s. A rather interesting release which occurred at the West Virginia site in the 1860s-1870s (possibly in response to Civil War activities) was followed by a fairly severe decline beginning in the 1880s. This decline, which coincided with a period of high spruce mortality, was reported by Millspaugh (1891) and Hopkins (1899) and is discussed in more detail by Adams and Stephenson (1989).

TABLE 2. Summary data on spruce trees from which increment growth cores were collected in spruce and spruce-fir forests in four different regions of the world. Values given for DBH, radial growth, and number of rings are sample means \pm SE.

Parameter	West Virginia	Montana	Alaska	India
Number of trees cored	21	26	15	12
DBH(cm)	60.3 \pm 7.9	70.9 \pm 2.9	36.8 \pm 1.1	62.4 \pm 2.4
Number of rings	200 \pm 9.6	220 \pm 8.5	159 \pm 2.6	96 \pm 6.5
Maximum number of rings	368	344	171	129
Radial growth (mm):				
1960-1979	23.5 \pm 2.8	25.0 \pm 2.5	16.4 \pm 1.7	55.2 \pm 4.1
1940-1959	30.4 \pm 2.9	26.9 \pm 2.7	16.2 \pm 1.14	55.2 \pm 4.1
1920-1939	44.4 \pm 4.2	24.7 \pm 2.0	23.1 \pm 1.3	54.3 \pm 6.4
1900-1919	41.4 \pm 3.4	26.0 \pm 2.2	20.3 \pm 1.4	38.9 \pm 2.5
Radial growth for the 1960-1979 interval/total radial growth from 1900 (%)	16.8	24.4	21.6	28.3

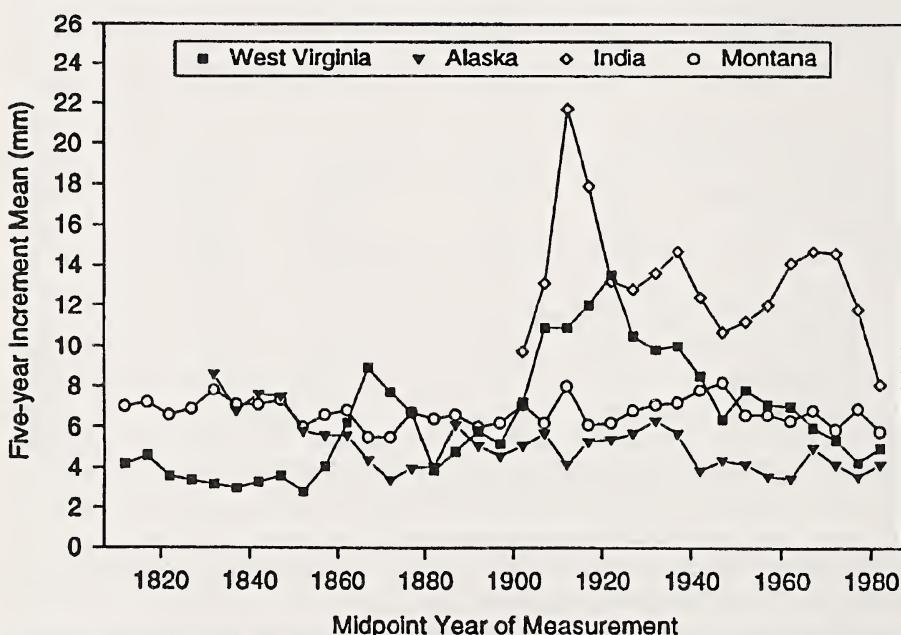


FIGURE 1. Incremental growth (based on five-year means) for cored spruce trees in the four study areas.

A pre-1950 period of increased growth for red spruce (which, in our data, became apparent following the late 1800s decline) has been reported by other researchers in the northern Appalachians (e.g., Reams and Huso, 1990; Van Deusen, 1990). Van Deusen (1990) suggested that possible stand disruption during

TABLE 3. Summary data on soils associated with spruce and spruce-fir forests in four different regions of the world. Values given are sample means ($n=4$).

Parameter	West Virginia	Montana	Alaska	India
Organic matter (%)	56	20	2	14
pH	3.1	4.1	5.3	6.5
Calcium (ppm)	131	194	406	1200 +
Magnesium (ppm)	27	39	120 +	120 +
Potassium (ppm)	62	65	27	80
Phosphorus (ppm)	26	7	3	16
Zinc (ppm)	4.7	4.6	0.3	3.6
Nitrogen (ppm)	22	9	4	22
Soluble salts (ppm)	768	226	< 100	234

the 1930s and 1940s by insects, disease, or anthropogenic factors may have been responsible for a period of release that resulted in abnormally fast growth. This, in turn, established conditions for the recent period of decline. The disruption in the West Virginia stand occurred much earlier (i.e., late 1800s), with the increased growth beginning just after 1900. During the early part of the present century, extensive logging operations were still ongoing in the general vicinity of the study area in West Virginia. However, such operations would not have affected this study area, since it is considered to be an old-growth forest that has not been subjected to extensive human disturbance (Core 1966). Another type of disturbance, birch dieback, has been documented in some stands of red spruce in Maine by Reams and Huso (1990). Yellow birch (*Betula lutea* Michx. f.) does share dominance with spruce in the West Virginia study area. However, such a scenario is doubtful for our stand, since any associated dieback of birch was never mentioned in the well-documented decline of red spruce in the late 1800s.

A fairly severe reduction in growth of red spruce, commencing in the 1920s and continuing until around 1950, followed the earlier period of increased growth (Figure 1). The decline is not apparent in Table 2 since 1920-1939 included the period of maximal growth of these trees in the early 1920s. This decline most likely can be attributed to natural intrastand competition following survival and subsequent release of this cohort of trees from prior disturbance. It would appear that the pattern of decreasing growth had leveled off in the 1940s and 1950s. However, trees at this site then entered another period of consistent (though gradual) diminishing growth until 1980. McLaughlin et al. (1990) have suggested that high atmospheric inputs of SO_4 and NO_3 to soils already very acidic can reduce levels of both calcium and magnesium, while raising levels of aluminum to the point of potential toxicity to red spruce. The combination of these factors may be adversely affecting growth and physiology of red spruce trees at high elevation sites in the Great Smoky Mountains National Park. Interestingly, our data (Table 3) indicate that considerably lower values of pH, calcium, and magnesium exist for soils at the West Virginia site than for soils at the other sites. Conversely, values for soils in

India (where growth for the most recent time period was greatest) were the highest of any site we studied. Acid deposition is well-documented in West Virginia (Helvey and Kunkle, 1986; Helvey and Edwards, 1987; Edwards and Helvey, 1991) and our own recent analyses of soils from this region of West Virginia often show relatively high levels of aluminum (unpublished data). Given this information, our data would tend to support the hypothesis of McLaughlin et al. (1990).

Data from the 1980s and into the 1990s (Adams and Stephenson, 1992) do suggest an amelioration of the recent growth decline of red spruce in the mid- and southern Appalachians. It is interesting to note that many of the red spruce trees included in our study were growing at a similar and even slower rate during the early 1800s as compared to their growth during the mid- and late 1900s. Perhaps these trees merely are returning to their pre-1860s growth rate. In any case, and not surprisingly, the results of the present study (although based on limited data) clearly demonstrate that the pattern of growth for each of the four species of spruce we studied is indeed unique.

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Biased Random Walks

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The work to follow grew out of an attempt to generalize a standard random walk problem. The orderly presentation of our mathematics does not represent the process of developing the ideas. That process was actually quite haphazard as befits the subject.

A Standard Problem.

Let us suppose that a random walk takes place on the linear array of points $x = 1, 2, 3, \dots, N$. On each "go" from an interior point, $x = 2, 3, 4, \dots, N - 1$, the random walker must take a unit step either to his right or to his left. The probability of a move in either direction is $1/2$.

$$x = \begin{matrix} \cdot & \cdot & \cdot & \cdots & \cdot & \cdot \\ 1 & 2 & 3 & \dots & N-1 & N \end{matrix}$$

FIGURE 1. The Linear Array

Let $p(x)$ represent the probability of reaching the endpoint $x = N$ from $x = 1, 2, 3, \dots, N - 1, N$. Both $x = 1$ and $x = N$ serve as traps from which there is no escape. Thus $p(1) = 0$ and $p(N) = 1$. The probabilities must satisfy the average value condition

$$p(x) = (1/2)p(x - 1) + (1/2)p(x + 1) \quad (1)$$

on the interior of the array. This equation implies that $p(x) = x/N$, and further computations show that $p(x)$ is the unique function satisfying both Equation 1 and the boundary condition $p(1) = 0$, $p(N) = 1$. Finding $p(x)$ is an example of a one-dimensional Dirichlet problem (Doyle and Snell, 1984; Boyd and Raychowdhury, 1989; Boyd and Raychowdhury, 1992a; Boyd and Raychowdhury, 1992b).

An Extension of the Problem.

We asked the question: "Are there functions $f(x)$ such that Equation 1 when amended to

$$p(x) = \frac{1}{2} \left(\frac{f(x - 1)}{f(x)} \right) p(x - 1) + \frac{1}{2} \left(\frac{f(x + 1)}{f(x)} \right) p(x + 1) \quad (2)$$

will uniquely define a probability of reaching $x = N$ from an interior point of the array?"

Restrictions upon the functions are that $f(x) \neq 0$, $f(x - 1)/f(x)$ and $f(x + 1)/f(x)$ are positive, and

$$\frac{1}{2} \left(\frac{f(x-1)}{f(x)} \right) + \frac{1}{2} \left(\frac{f(x+1)}{f(x)} \right) = 1. \quad (3)$$

Equation 3 is necessary since the two ratios of functions represent the probabilities of moving to the left and right from the point with coordinate x . This equation can be rewritten as

$$(1/2)f(x-1) + (1/2)f(x+1) = f(x)$$

which repeats the average value property of Equation 1. Therefore, any such function $f(x)$ must be linear.

A Solution of the Extended Problem.

Equation 2 can be rewritten as

$$[f(x+1)p(x+1) - f(x)p(x)] - [f(x)p(x) - f(x-1)p(x-1)] = 0$$

which suggests that the second of the successive differences in the product function $f(x)p(x)$ for unit increments in x is zero. Therefore, we are led to consider $f(x)p(x) = Ax + B$ where the constants A and B need to be determined from the choice of $f(x)$ and the boundary conditions on $p(x)$.

For example, suppose that $f(x) = x$, $p(1) = 0$, and $p(N) = 1$ so that $p(x) = (Ax + B)/x$. Then $p(1) = 0$ implies that, $A = -B$ and $p(N) = 1$ implies that $A = N/(N-1)$. Thus $p(x) = (N/(N-1))((x-1)/x)$ and further computation shows that $f(x)$ satisfies Equation 3 while $p(x)$ satisfies Equation 2.

Equations 2 and 3 also imply that the maximum and minimum values of $p(x)$ must occur at the endpoints of the walk ($x = 1$ and $x = N$). Therefore, two probability functions $p(x)$ and $p'(x)$ which agree at $x = 1$ and $x = N$ must necessarily be identical on all of $\{1, 2, 3, \dots, N\}$.

Example 1.

We now give a particular example to indicate the sort of computations that can be made. Let $N = 4$ and $f(x) = x$ so that $p(x) = \frac{4}{3} \left(\frac{x-1}{x} \right)$. Then $p(1) = 0$, $p(2) = \frac{2}{3}$, $p(3) = \frac{8}{9}$ and $p(4) = 1$.

We can also construct the 4-by-4 transition matrix ($p(i,j)$) in which $p(i,j)$ represents the probability of a move from $x = i$ to $x = j$ on a single step (Kemeny et al., 1965). The definition of our random walk implies the following:

$$P(i,j) = 0 \text{ if } |i - j| > 1,$$

$$p(1,1) = 1 \text{ and } p(4,4) = 1,$$

$$p(1,2) = p(4,3) = 0, \text{ and}$$

$$p(2,1) = \frac{f(1)}{2f(2)}, p(2,3) = \frac{f(3)}{2f(2)}, p(3,2) = \frac{f(2)}{2f(3)}, p(3,4) = \frac{f(4)}{2f(3)}.$$

Therefore,

$$(p(i,j)) = \begin{pmatrix} 1 & 0 & 0 & 0 \\ \frac{1}{4} & 0 & \frac{3}{4} & 0 \\ 0 & \frac{1}{3} & 0 & \frac{2}{3} \\ 0 & 0 & 0 & 1 \end{pmatrix}.$$

The matrix $(q(i,j)) = (p(i,j))^n$ gives the probabilities of moving from $x = i$ to $x = j$ in exactly $n = 1, 2, 3, \dots$ steps. That is, $q(i,j)$ is the probability of reaching $x = j$ from $x = i$ in n steps. Readers can verify for themselves that the entries of

$$(p(i,j))^2 = \begin{pmatrix} 1 & 0 & 0 & 0 \\ \frac{1}{4} & \frac{1}{4} & 0 & \frac{1}{2} \\ \frac{1}{12} & 0 & \frac{1}{4} & \frac{2}{3} \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

are as claimed.

Since we have computed the probabilities of reaching $x = 4$ for all walks taken to their conclusion and since $p(1) = 1 - p(4)$, we can give the nonobvious limit for $(p(i,j))^n$ as n tends to infinity:

$$\lim_{n \rightarrow \infty} (p(i,j))^n = \begin{pmatrix} 1 & 0 & 0 & 0 \\ \frac{1}{3} & 0 & 0 & \frac{2}{3} \\ \frac{1}{9} & 0 & 0 & \frac{8}{9} \\ 0 & 0 & 0 & 1 \end{pmatrix}.$$

This limit can be verified by the computation

$$(p(i,j)) \cdot \begin{pmatrix} 1 & 0 & 0 & 0 \\ \frac{1}{3} & 0 & 0 & \frac{2}{3} \\ \frac{1}{9} & 0 & 0 & \frac{8}{9} \\ 0 & 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ \frac{1}{3} & 0 & 0 & \frac{2}{3} \\ \frac{1}{9} & 0 & 0 & \frac{8}{9} \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

A Two Dimensional Random Walk.

Let us now consider a random walk on the square array $\{1, 2, 3, \dots, N\} \times \{1, 2, 3, \dots, N\}$. Suppose that the sides of the square are traps. Once the walk reaches a side, the walk becomes one dimensional with traps at the vertices $(1, 1)$, $(1, N)$, (N, N) , and $(N, 1)$. We are interested in reaching (N, N) from (x, y) . We denote the probability of that event by $p(x, y)$.

On each side, the walk is prescribed by Equation 2. At the interior lattice point (x, y) which has the four nearest neighbors $(x - 1, y)$, $(x + 1, y)$, $(x, y - 1)$, and $(x, y + 1)$, we have the average value requirement

$$p(x, y) = \frac{1}{4} \left[\frac{f(x - 1, y)}{f(x, y)} p(x - 1, y) + \frac{f(x + 1, y)}{f(x, y)} p(x + 1, y) + \frac{f(x, y - 1)}{f(x, y)} p(x, y - 1) + \frac{f(x, y + 1)}{f(x, y)} p(x, y + 1) \right]$$

to replace Equation 2.

Straightforward computations show that, for $p(1, 1) = p(1, N) = p(N, 1) = 0$, $p(N, N) = 1$ and $f(x) = x$, $f(y) = y$, $f(x, y) = f(x)f(y)$, the function

$$p(x, y) = \frac{N^2}{(N - 1)^2} \left(\frac{x - 1}{x} \right) \left(\frac{y - 1}{y} \right)$$

uniquely satisfies the problem and analogies with the one dimensional case hold as expected. The problem and its product solutions can be generalized to higher dimensions.

Example 2.

If we let $N = 4$, then $p(x, y) = \frac{16}{9} \left(\frac{x - 1}{x} \right) \left(\frac{y - 1}{y} \right)$. We display the values of $p(x, y)$ in the table below.

		x			
		1	2	3	4
		1	0	0	0
y	2	0	$\frac{4}{9}$	$\frac{16}{27}$	$\frac{2}{3}$
	3	0	$\frac{16}{27}$	$\frac{64}{81}$	$\frac{8}{9}$
	4	0	$\frac{2}{3}$	$\frac{8}{9}$	1

TABLE 1. Values of $p(x,y)$ for $N = 4$.

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Use of Dendrochronological Methods to Estimate an Ecological Impact Date of the Chestnut Blight

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ABSTRACT

The slope of Bald Knob in Giles County, Virginia, is a former chestnut dominated community that has been the site of two previous forest ecology studies. Analysis of the chronology of basal area increment growth (BAI) of 26 red oaks at least 79 years old clearly shows a dramatic growth release beginning in the mid-1920's. Because of the former chestnut dominance, the timing of its elimination from the canopy, and the extraordinary growth trend of these older red oaks, I attribute the 1920's release to the dynamic changes caused by the chestnut blight. Dendrochronological methods and limitations are discussed.

INTRODUCTION

The American chestnut (*Castanea dentata* [March.] Borkh.) was a codominant species with red oaks (*Quercus rubra* L.), chestnut oaks (*Q. prinus* L.), and white oaks (*Q. alba* L.) in many of the upland forests of eastern North America (Braun, 1950) until the chestnut blight (*Cryphonectria parasitica* [Murr.] Barr) was introduced in New York in 1904 (Gravatt and Marshall, 1926). The result has been the elimination of all canopy chestnuts in the area. Individuals are now only present in the form of emergent root sprouts with little capacity to grow above the subcanopy.

E. L. Braun surveyed two sites on the slope of Bald Knob, Giles County, Virginia, in 1932. She reported that the canopy (stems > 10 cm in diameter at breast height (DBH)) was composed of 84.6% and 56% of standing American chestnuts at the two sites. Red oaks were the second most abundant species and represented 11.1% and 22%, respectively (Braun, 1950).

Dendrochronological analysis has long been used to uncover climatic and environmental impacts on trees (Schweingruber, 1989). The typical trend of radial increment growth (ring width) of an unstressed tree is thought to be curvilinear, generally following a negative exponential curve (Phipps and Whiton, 1988). Specifically, Phipps (1985) has suggested that the basal area increment growth (BAI) of canopy trees such as oaks are curvilinear. Note that the addition of smaller rings each year could contribute a constant BAI (because the tree's diameter increases yearly).

The application of cubic splines (mathematical functions) to tree ring series was developed to separate the "growth" from "non-growth" components of BAI chronologies (Figure 1) (Cook and Peters, 1981). The "growth" component is the

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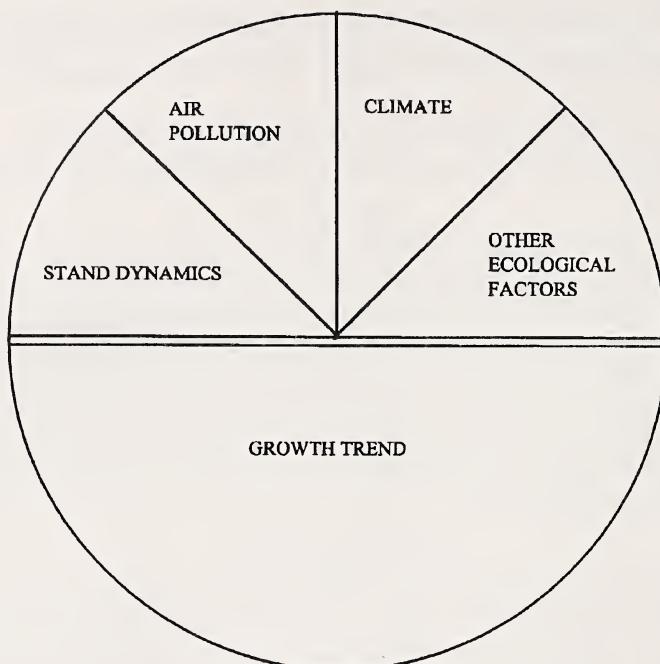


Figure 1. The result of applying mathematical cubic splines to tree ring series: the separation of the biotic growth component (growth trend) from growth related to other ecological factors.

tree's uninfluenced biotic factor, whereas the "non-growth" component is increase or decrease in growth resulting from stand dynamics (including competition and disturbances), climate, and pollution. Although the non-growth component consists of many influences on tree growth, in this study I focus on stand dynamics, which was the most dominant of these effects on Bald Knob. My motive in this project was to examine the response of the now dominant species in individuals that predated the chestnut blight's disturbance.

METHODS

Codominant tree species present in the area of Braun's survey (as relocated by S. L. Stephenson) were cored 1.37 meter above the ground using a standard increment borer (see Phipps, 1985). Many attempts at coring older white oaks and red oaks were unsuccessful because of center heart rot. A total of 50 cores (1 from each tree) were collected (34 red oaks, 5 red maples (*Acer rubrum* L.), 4 white oaks, and individuals from 7 other species). Cores were dried, glued in grooved blocks, and sanded down with 120, 220, and 400 grit sand paper (Phipps, 1985; Schweingruber, 1989). Ages were estimated by counting rings under a dissecting microscope.

Of the 50 cores, 26 red oak cores predated the blight and were sufficiently old to have shown any response. Each ring of the 26 pre-blight existing red oaks was measured to 0.01 mM with digital calipers. Missing and extra growth rings were checked by overlaying graphs of the BAI trends using the computer program PLOT

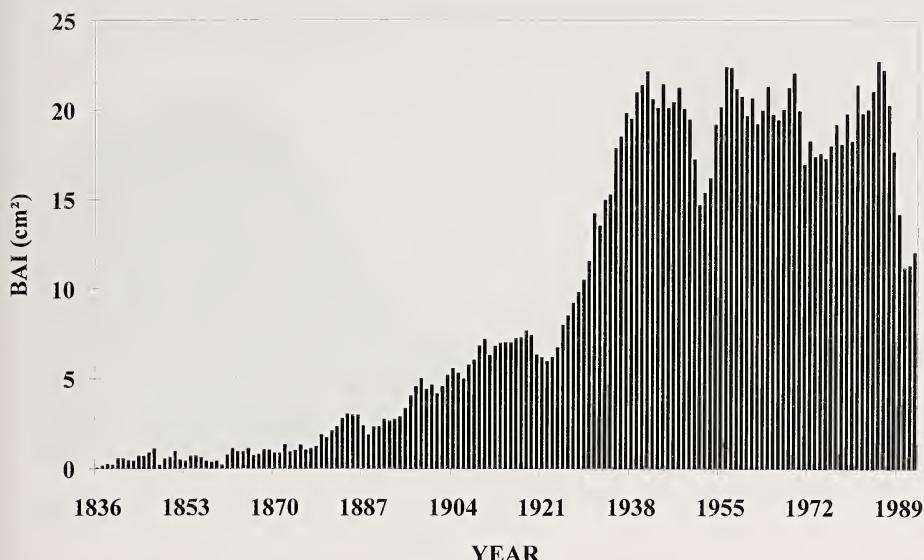


Figure 2. Mean basal area increment (BAI) of 26 red oaks on Bald Knob.

(Phipps, 1989). Where the cores did not hit the center of tree, the pith age and ring widths were estimated by completing the missed concentric rings with a compass (Norton et al., 1987; Arno and Sneed, 1977).

Using the program AREA (Phipps, 1989), time series of the mean BAI, the smoothed (detrended using a cubic spline) basal area increment (SBAI), and the upper and lower 95% confidence limits were created. These results were calculated by applying a cubic spline of 60 years to the data (Cook and Peters, 1981). Additionally, an index of the individual tree responses to the non-growth components was calculated. The ring width index (RWI) was derived by dividing the BAI by the SBAI (Phipps, 1989).

RESULTS

Of the 34 red oak cores extracted, 26 were at least 79 years old. The other eight had a mean age of 60 years (ranging from 55 to 63 years). I believe, as did Stephenson (1986), that the latter were red oaks newly recruited just after the blight. Similarly, none of red maple cores was older than 65 years of age. Because of the high frequency of center wood rot, the small collection of white oaks could not provide useful information. Thus, I restricted my analysis of tree rings to the older red oaks only.

The 26 pre-blight existing red oak cores ranged in age from 79 to 157 years. The mean age was 103 years. Figure 2 shows the calculated and graphed mean values of BAI for the 26 red oaks. These unmanipulated data show the mean two dimensional wood growth per ring per year. A clear and sustained increase in BAI can be seen during the mid 1920's. Two other sequences of increasing ring widths occurred in the early 1950's and 1970's (see Figure 2).

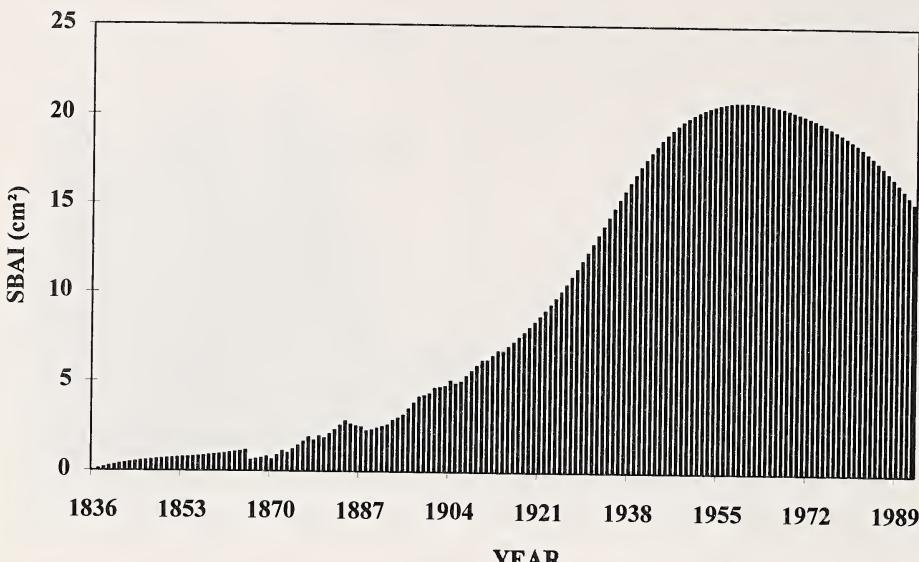


Figure 3. Mean smoothed basal area increment (SBAI) of 26 red oaks on Bald Knob.

By applying a 60 year cubic spline to each core's BAI, roughly 50% of the variance was removed over each 60 year cycle, and a smoothed sequence was obtained for each core (Phipps, 1989). These were then averaged by year of formation to give the mean SBAI values in Figure 3. Although the calculation of SBAI is a representation of the often linear growth trend only (Phipps, 1989), an unusually large increase in SBAI is included here in the 1920's. Figure 4 gives the SBAI with the upper and lower 95% confidence limits. Figure 5 displays the RWI, the ratio between BAI and SBAI (presumably the non-growth components). The average RWI (Figure 5) includes both stand-wide as well as local responses. The index values before 1889 have been removed because fewer than 10 trees were older than 104 years. A small sample size increases variance and poorly fitted curves for young trees, yielding wildly ranging indices.

DISCUSSION

My results show that there was a growth release throughout the stand in the mid-1920's. This result is not a reflection of averaging strong responses from a few stems with minimal changes in others, because the release (defined by a 5 year sustained increase in BAI) (Canham, 1985) was seen in 81% of the cores. In contrast, the visibly strong responses of the early 1950's and 1970's (see Figures 2 and 5) was seen in only 12% and 4% of the cores, respectively. This suggests that the 1920's release is, indeed, stand-wide, and a response to the chestnut blight.

Some Limitations of Tree Ring Smoothing

The graph of BAI versus time represents several components of an individual tree's growth: normal biotic growth, stand dynamics (including competition and disturbance), climate, pollution, and other minor factors. The purpose of smoothing the BAI series with splines (e.g., Figure 3) is to identify and separate the normal

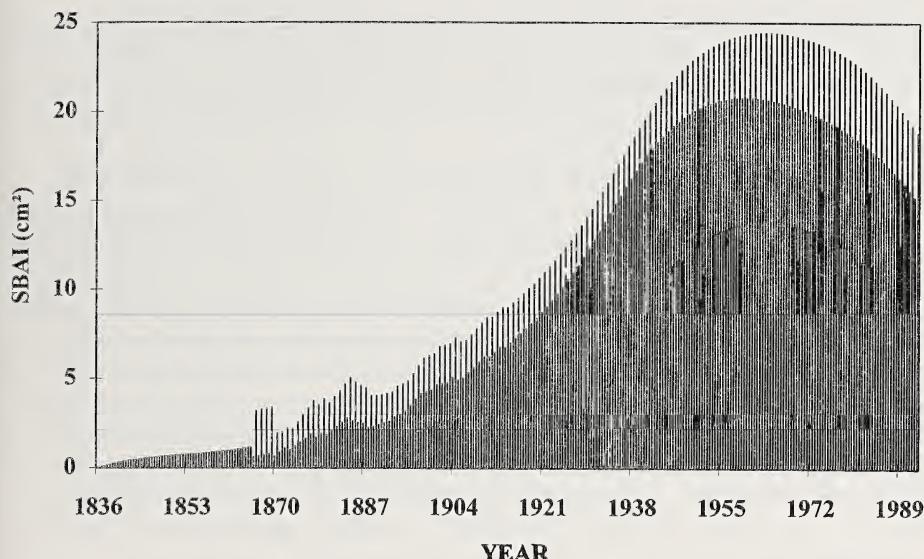


Figure 4. Mean SBAI of 26 red oaks on Bald Knob with the upper and lower 95% confidence limits.

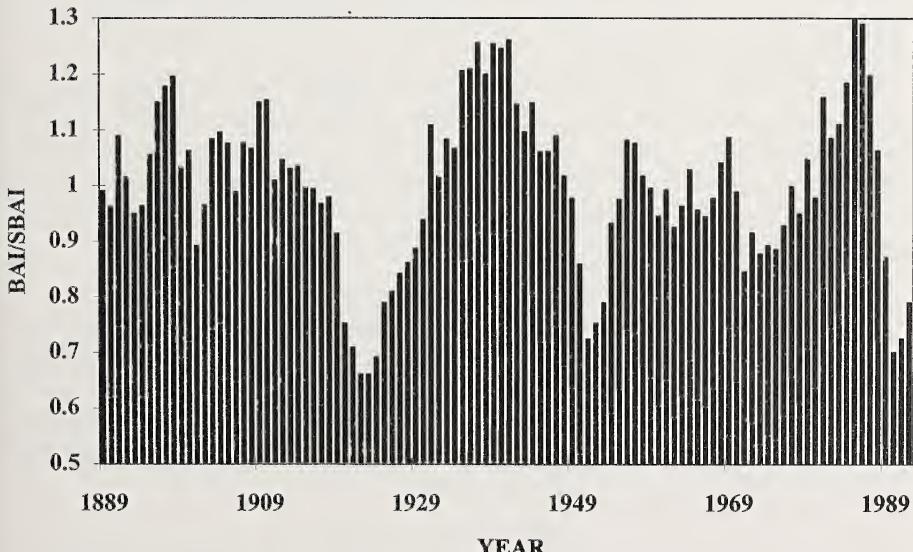


Figure 5. Mean ring width index (RWI) of 26 red oaks on Bald Knob.

growth trend component of the dendrochronological series (Phipps, 1989). However, in the case of this series, the major release of the 1920's was evident in the smoothed trend in a majority of the trees. Thus, part of the response to the non-growth factors is part of the SBAI. Therefore, the RWI underestimates the response of the 1920's release.

An alternate spline length does not solve this problem for these ring series. A stiffer spline length, i.e., greater than 60 years, would produce a more accurate RWI that would better reflect the actual release; however, the RWI would also include components of the growth trend that we would not want to separate from the SBAI. Conversely, a decreased spline length would better represent the growth trend of the trees; however, it would also further underestimate the non-growth component in the RWI. A limitation in the currently available dendrochronological methods is that they were developed mainly for use on open, western forest stands where climate and not pollution or tree-tree interactions are determining the main annual growth fluctuations (Cook and Peters, 1981). Eastern, closed-canopy stands are often affected by factors other than climate. Other smoothing techniques to identify growth trends in stands affected by major disturbances need to be developed.

What Figure 3 illustrates is that the disturbances of the early 1950's and 1970's can be "subtracted" or smoothed, because of their local nature. Also, the larger confidence limits in the mid 1920's than the confidence limits surrounding the subsequent releases (Figure 4) support the hypothesis of a stand-wide release. The sum of all factors other than the growth trend (the RWI), is given in Figure 5. The mid 1920's release, the response of the early 1950's and 1970's, as well as yearly climatic variations are present. Note that the release of the mid-1920's is under-represented in Figure 5 because much of the growth boost remained with the separated growth trend in Figure 3 (owing to the limitations of mathematical smoothing using cubic splines).

I see no other reasonable postulate than to explain the 1920's release in BAI experienced by older red oaks on Bald Knob as a direct response to the death of the American chestnuts. An elimination of 70% of the canopy trees provided the red oaks with favorable light conditions, high nutrient levels, and minimal competition. Thus, I assign an ecological impact date of the chestnut blight on the now dominant red oaks to be between 1924 and 1927.

ACKNOWLEDGMENTS

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JEFFRESS RESEARCH GRANT AWARDS

The Allocations Committee of the Thomas F. and Kate Miller Jeffress Memorial Trust has announced the award of Jeffress Research Grants to the institutions listed below to support the research of the investigator whose name is given. The Jeffress Trust, established in 1981 under the will of Robert M. Jeffress, a business executive and philanthropist of Richmond, supports research in chemical, medical and other natural sciences through grants to non-profit research and educational institutions in the Commonwealth of Virginia. The Jeffress Research Grants being announced here have been awarded in 1994.

The Jeffress Memorial Trust is administered by NationsBank of Virginia, N. A. Additional information about the program of the Trust may be obtained by writing to: Advisor, Thomas F. and Kate Miller Jeffress Memorial Trust, NationsBank, Trust Division , P. O. Box 26903 , Richmond, VA 23261.

Deborah C. Bebout, College of William and Mary. Mechanistic Comparison of Evolutionarily Divergent Peptidyl α -hydroxylating Monooxygenases. \$16,000 (one year).

Stephen J. Beebe, Eastern Virginia Medical School. Molecular Genetic Characterization of cAMP Signal Transduction. \$10,000 (one year renewal).

Amy H. Bouton, University of Virginia. Molecular Cloning and Characterization of the PP6^{src}-associated Protein p130. \$20,488 (one year renewal).

Karen J. Brewer, Virginia Polytechnic Institute and State University. The Reductive Coupling of Carbon Dioxide Using Novel Bimetallic Catalysts. \$20,189 (one year renewal).

William G. Broaddus, George T. Gillies, John T. Stewart, Virginia Commonwealth University. Improved Medical Imaging for Neurological Procedures. \$28,950 (one year).

Daniel J. Burke, University of Virginia. Identifying Novel Factors that Regulate Spindle Function. \$10,000 (one year renewal)

Jiande Chen, University of Virginia. Noninvasive Measurement of Migrating Motility Complex of the Human Small Intestine Using Surface Electrodes. \$20,000 (one year renewal).

Claire Cronmiller, University of Virginia. Molecular and Genetic Characterization of *1(3)1344*, a Gene Required for Ovarian Follicle Formation in *Drosophila*. \$18,550 (one year).

Alan C. Dalkin, University of Virginia. Regulation of Gonadal Activin Receptor Gene Expression. \$25,685. (one year).

- Martin J. Dudziak, Virginia Commonwealth University. A Study of Cytoskeletal Structural Variations and Classifications Using Scanning Probe Microscopy and Neural Networks. \$19,800 (one year).
- M. Samy El-Shall, Virginia Commonwealth University. Gas Phase Polymerization Catalyzed by Metal Cations. \$ 10,000 (one year renewal).
- M. G. Finn, University of Virginia. Asymmetric Synthesis of Allenes with Titanium-Substituted Ylides. \$21,900 (one year).
- Anthony Frankfurter, University of Virginia. Antisense Peptides as Probes for Characterizing Microtubule Protein. \$10,000 (one year renewal).
- Troy M. Glembot, Eastern Virginia Medical School. Effects of Endotoxemia on Skeletal Muscle Microcirculation. \$22,589 (one year).
- Frederico Gonzalez-Fernandez, University of Virginia. Molecular Analysis of Interphotoreceptor Retinoid-Binding Protein. \$10,000 (one year renewal)
- Samuel A. Green, University of Virginia. Rapid Lysosomal Targeting of Amyloid Precursor Protein. \$20,800 (one year).
- Keith Griffioen, College of William and Mary. Spin Structure of the Proton and Neutron. \$14,194 (one year).
- Shelley Halpain, University of Virginia. Regulation of Dendritic Microtubules in Neurons. \$10,000 (one year renewal)
- Daniel J. Haisenleder, University of Virginia. Intracellular Regulation of Prolactin Gene Expression. \$22,000 (one year).
- Colleen Jackson-Cook, Virginia Commonwealth University. Genetic Factors in Human Sperm Aneuploidy. \$10,000 (one year renewal).
- Robert H. Kretsinger, University of Virginia. Determination of the Crystal Structure of 3-Deoxy-D-manno-2-octulosonate-8-phosphate Synthase (KDOPsyn). \$ 10,000 (one year renewal).
- Thomas J. Lauterio, Eastern Virginia Medical School. Role of Growth Factors and Thyroid Hormones in Nerve Regeneration. \$21,270 (one year).
- Susan E. Lazendorf, Eastern Virginia Medical School. In Vitro Maturation of Cynomolgus Monkey Oocytes. \$12,800 (one year).
- Mark Lee, University of Virginia. Exploration of Microwave and Millimeter-Wave Antennas Using High-Temperature Superconductor Thin Films. \$27,300 (one year).

Joyce A. Lloyd, Virginia Commonwealth University. Developmental Regulation of the Human Fetal and Adult *B*-like Globin Genes. \$8,700 (one year renewal).

Francine Marciano-Cabral, Virginia Commonwealth University. The Chemotactic Response of *Naegleria fowleri* Amoeba. \$10,000 (one year renewal).

Laura K. Moen, Old Dominion University. Cloning and Expression of HTLV-1 Reverse Transcriptase. \$10,000 (one year renewal).

Mary C. Mahony, Eastern Virginia Medical School. Regulation of the 5a-reductase Enzyme within the (non-human primate) Epididymis. \$20,758 (one year).

Mitzi Nagarkatti, Virginia Polytechnic Institute and State University. Role of Adhesion Molecules in Experimental Immunology. \$10,000 (one year renewal).

Sergio Oehninger and Ke-Wen Dong, Eastern Virginia Medical School. Expression and Characterization of Human Zona Pellucida Protein 3. \$21,090 (one year).

William A. Petri, Jr., University of Virginia. Characterization of the Immune Response to *Leishmania chagasi* heat shock protein 70(hsp70) in patients with Leishmaniasis. \$23,144 (one year).

Robert D. Pike, College of William and Mary. Preparation and Elaboration of Novel (Cyclohexadienyl) Manganese Complexes- \$10,000 (one year renewal).

Ary S. Ramoa, Virginia Commonwealth University. Activity-Dependent Mechanisms in the Lateral Geniculate Nucleus During Development. \$13,834 (one year).

James L. Riopel, University of Virginia. Cellular and Biochemical Basis of Host Resistance During the Penetration Phase of *Striga asiatica*. \$16,250 (one year).

Emilie F. Rissman, University of Virginia. Multiple Forms and Functions of Gonadotropin-Releasing Hormone(GnRH), \$10,000 (one year renewal).

Joseph K. Ritter, Virginia Commonwealth University. Cellular Models to Study Roles of UDP-glucuronosyl Transferases in Cancer Protection. \$23,152 (one year).

James R. Roesser, Virginia Commonwealth University. Tissue-Specific Regulation of Alternative RNA Splicing. \$14,194 (one year).

Paul K. Ross, Virginia Commonwealth University. Synthesis and Spectroscopic Characterization of Models for Nickel-Containing Metalloenzymes. \$10,000 (one year renewal).

Steven M. Roth and Jock Wheeler, Eastern Virginia Medical School. Evaluation of the Role of Monocytes in Pretreatment of Expanded Polytetrafluoroethylene Grafts Prior to Endothelial Cell Seeding. \$14,401 (one year).

Sarah E. Swank, Bridgewater College. Forest Regeneration: Interactions among Tree Seedlings, Ferns and Mammalian Browsers. \$8,312 (one year).

Richard A. Walker, Virginia Polytechnic Institute and State University. Characterization of Motor-Microtubule Interaction Sites. \$24,956 (one year).

Fang-Shen Wu , Virginia Commonwealth University. Induction of Gene Expression for Binding Proteins by Calcium Perturbation in Germinating Pollen Cells. \$10,000 (one year renewal).

VIRGINIA ACADEMY OF SCIENCE EXECUTIVE COMMITTEE MEETING MINUTES

March 4, 1995

Present: Elsa Q. Falls (President), Thomas O. Sitz (President-Elect), Rosemary Barra (Secretary), Kenneth C. Jacobs (Treasurer), Don Cottingham (VJAS Director), Blanton M. Bruner (Executive Secretary-Treasurer), James P. O'Brien (1993-94 President; Chair, Fund Raising Committee), Rae Carpenter (Co-Chair, Local Arrangements Committee - VMI), Richard B. Minnix (Co-Chair, Local Arrangements Committee - VMI), James H. Martin (Editor, Virginia Journal of Science).

The meeting was called to order at 10:03, and the agenda for the meeting was adopted with the Local Arrangement Committee moved to the top of the agenda. The minutes from the Executive Committee meeting of November 6, 1994 were approved.

OFFICERS' REPORTS

Local Arrangements - Rae Carpenter

Rae Carpenter distributed a packet of information for the Annual Meeting. He indicated that the paper sessions for the Senior Academy will be held in Mallory Hall and the Science Building and that these two buildings are connected. The Junior Academy sessions will require three buildings, Scott-Schip Hall in addition to Mallory Hall and the Science Building. The Aeronautical and Aerospace Sciences and the Microbiology and Molecular Biology sections will not meet this year. A potential insurance problem related to the use of school buses for the Junior Academy was avoided when the superintendent of Rockbridge County Schools indicated that their insurance policy will cover the buses and drivers. A list of exhibitors and supporters of the meeting (ex. the Rockbridge County Schools) will be included in this year's booklet.

President - Elsa Q. Falls

President Falls distributed a copy of her report (attached), and emphasized the following points:

- The LAC meeting was held on January 10th, and plans for the Annual Meeting are progressing nicely. She thanked the LAC for all of their work.
- The request for a state travel exemption for attending the VAS meeting was denied. Each person must seek an exemption through his/her own institution.
- The Biology Planning Committee of the Virginia Community Colleges will be meeting in Charlottesville on March 31 and April 1, 1995. VAS membership brochures will be available at the meeting.

VJAS Director - Don Cottingham

Don Cottingham reported that the VJAS received 1,875 papers this year, an increase of approximately 100 over last year, and that the papers were being sent to the readers today. He has not received any concerns from the sponsors regarding the motel and busing arrangements for the meeting at VMI. President Falls thanked Don for all his hard work and wished him a good trip back to Richmond.

President-Elect - Thomas O. Sitz

Tom Sitz reported that the Aeronautical and Aerospace Sciences and Microbiology and Molecular Biology sections will not be running sessions at the Annual Meeting. The ASM meeting in Washington conflicts with the VAS meeting. He indicated that the number of papers for the meeting looked good.

It was noted that in November Gene Maurakis will complete his first year as Associate Director of the VJAS and that it may be time to appoint a committee for his annual review.

Jim O'Brien made the following motion:

The Executive Committee recommends to Council that the President appoint a committee to review the agreement and performance thereof between the Virginia Science Museum and VAS regarding the VJAS Associate Director position. This meeting should be held in early summer.

The motion was seconded by Ken Jacobs and passed unanimously.

Secretary - Rosemary Barra

No report

Treasurer - Kenneth C. Jacobs

Ken Jacobs presented the current membership figures for the VAS and indicated that the membership had increased by 18.

Change from 11/6/94

Regular	713	+ 9
Student	307	+ 7
Individual/Sustaining	26	0
Individual/Contributing	55	0
Life	31 (+ 4 Emeritus)	+ 2
Business/Regular	12	0
Business/Sustaining	4	0
Business/Contributing	1	0
Institutions	32	0
Patrons	?	?

The numbers are still comparable to February and November 1994, with a slight increase (+ 2%) due to those signing up for the VAS Annual Meeting at VMI. We know that we have some Patrons, but specific information on them has not yet been communicated to Lisa Martin.

Past President - James P. O'Brien

At the winter meeting of the VJAS a new seal was presented that ties the Junior Academy to the Senior Academy. The design of this seal is presently being reviewed. A video entitled "The VJAS Experience" has been produced and Jim O'Brien thanked Vernon Kramer and Pam Sumner for their work on this project.

The 75th Anniversary Committee developed a logo that it would like to incorporate into the VAS stationary and fund raising campaign. After a discussion of the symbols in the logo and suggestions that further work be done, Jim requested that the logo be approved at the May meeting.

The number of membership brochures is dwindling and the brochure needs to be reprinted before the Annual Meeting.

Jim O'Brien made the following motion:

That the Executive Committee approve the reprinting of 2000 membership brochures at an estimated cost of \$350 before the Annual Meeting at VMI.

The motion was seconded by Ken Jacobs and passed unanimously.

Executive Secretary-Treasurer - Blanton Bruner

Blanton Bruner did not have a formal report since the financial affairs of the Academy were under examination at the present time. He indicated that we finished last year with both the VJAS and VAS in the black and that the net results of the year were favorable.

Old Business

None

New Business

None

The meeting was adjourned at 11:55.

VIRGINIA ACADEMY OF SCIENCE COUNCIL MEETING MINUTES

March 4, 1995

Present: Elsa Q. Falls (President), Thomas O. Sitz (President-Elect), James P. O'Brien (Past President, 1993-94), Rosemary Barra (Secretary), Kenneth C. Jacobs (Treasurer; Councilor, Astronomy, Math and Physics Section), Gerald R. Taylor (Past President, 1991-92; Co-Chair, Constitution and Bylaws Committee; Co-chair, VJAS Search Committee; Nominations and Elections Committee), Vera B. Remsberg (Trustee, Science Museum of Virginia), Golde I. Holtzman (Past President, 1992-93; Chair, Archives Committee and 75th Anniversary Committee), James H. Martin (Editor, Virginia Journal of Science), Paul J. Homsher (Co-Chair, Finance and Endowment Committee), Richard B. Brandt (Jeffress-Gwathmey Trust; Chair, Long Range Planning Committee), D. Rae Carpenter (Co-Chair, Local Arrangements Committee; Chair, Futures Committee; Chair, Trust Committee), Judy Niehaus (Chair, Research Committee), Ertle Thompson (AAAS Representative), Blanton M. Bruner (Executive Secretary-Treasurer), Marion B. Lobstein (Councilor, Botany Section; Co-Chair, Public Affairs Committee), Carolyn B. Conway (Chair, Awards Committee; Councilor, Biology Section), Ralph P. Eckerlin, Co-Chair, Public Affairs Committee), J.J. Murray (Chair, Committee on the Environment), Robert Berquist (Councilor, Psychology).

The meeting was called to order by President Elsa Falls at 1:10 PM, and a motion to approve the agenda was passed. The minutes from the Council meetings on May 18, 1994 and November 6, 1994 were approved.

OFFICERS' REPORTS

President - Elsa O. Falls

President Falls distributed copies of her report (attached).

President-Elect - Thomas O. Sitz

The number of titles looks good for the May meeting. Two sections will not meet this year - Aeronautical and Aerospace Sciences and Microbiology and Molecular Biology. The Microbiology and Molecular Biology section is not meeting because of the conflict with the ASM meeting in Washington.

Richard Brandt pointed out that this will be the third year that Microbiology has not had a session. Following a discussion of possible ways to deal with this situation, Rae Carpenter made the following motion:

To inform the Microbiology and Molecular Biology Section that they will be dropped if they do not have a session at the 1996 Annual Meeting.

The motion was seconded by Jim Martin and passed unanimously.

Secretary - Rosemary Barra

No report

Treasurer - Kenneth C. Jacobs

Reported on the current membership figures for the VAS.

Change from 11/6/94

Regular	713	+ 9
Student	307	+ 7
Individual/Sustaining	26	0
Individual/Contributing	55	0
Life	31 (+ 4 Emeritus)	+ 2
Business/Regular	12	0
Business/Sustaining	4	0
Business/Contributing	1	0
Institutions	32	0
Patrons	?	?

The numbers are similar to last years. Although we know that there are some Patrons, Lisa Martin does not have that information.

Executive Secretary-Treasurer - Blanton Bruner

Blanton Bruner indicated that the financial affairs of the Academy were presently in the hands of the auditor. Both the VJAS and the VAS were in the black last year, and the Annual Meeting at JMU was most successful from a financial point of view.

Past President 1993-94 - James O'Brien

Jim O'Brien distributed a copy of his report (attached). He announced that the video "The VJAS Experience" was now available and he thanked the people at TCC for their work on this project. He also distributed a draft design for a 75th Anniversary logo that could be included on the Academy's stationary and fund raising activities.

Jim O'Brien made the following motion:

That Council approve a special budgetary item (in addition to funds already budgeted to the Academy's Representative on SMV's Board of Trustees) to fund

\$300 for the President and guest or designees to attend the Virginia Outstanding Scientists and Industrialists Awards Reception and Banquet.

Golde Holtzman seconded the motion.

Jim O'Brien stated that this is a fund raising activity for the Virginia Science Museum but that it would also be an opportunity to make contacts for future fund raising by the VAS.

Jim Murray spoke against the motion since we do not need to contribute to a fund raising activity for another organization.

Vera Remsburg pointed out that the purpose of the event is recognition of the outstanding work that has been done by the honored individuals and that it is not just a fund raiser.

Ken Jacobs offered an amendment to the motion which would change the amount to \$250, the price of two tickets. The amendment passed.

The amended motion was then passed with some negative votes.

Gerald Taylor proposed the following motion:

That Council should approve \$250 for Jim O'Brien as Chair of the Fund Raising Committee to attend the Virginia Outstanding Scientists and Industrialists Awards Reception and Banquet.

The motion was seconded by Richard Brandt who commented that visibility is important.

The motion passed with 1 negative vote and 1 abstention.

Elsa Falls thanked Jim for his continued hard work on behalf of the Academy.

Past President 1992-93 - Golde Holtzman

No report

Past President 1991-92 - Gerald Taylor

Gerald Taylor submitted a report on his January 6, 1995 meeting with Drs. Walter Witchey, Betty Blatt and Gene Maurakis (attached). He reviewed two possible organization charts with Walter Witchey and proposed the following motion to Council:

That we provide these two charts for Vera Remsburg to use in discussions with the Science Museum of Virginia.

The motion was seconded by Jim Murray and passed with one no vote.

Gerald Taylor also reported that Betty Blatt was unhappy over the lack of sufficient secretarial support for Gene Maurakis. He recommended that the Academy provide one-half daily secretarial staffing for the VAS and VJAS offices.

LOCAL ARRANGEMENTS COMMITTEE REPORTS

1995 Virginia Military Institute - D. Rae Carpenter and R.B. Minnix

The arrangements for the Annual Meeting at VMI were reviewed with the Executive Committee and the program is ready to be turned over to the president-elect for printing. Rae also reported that attempts are being made to arrange for local science students to assist with the VJAS meeting.

President Falls thanked Rae for the fine job he and the members of the Local Arrangements Committee are doing.

1996 Virginia Commonwealth University - Tom Haas

Absent

DIRECTORS AND REPRESENTATIVES REPORTS

VJAS Director - Don Cottingham

Elsa Falls reported that Don Cottingham was present at the Executive Committee meeting but has returned to Richmond to deal with the 1,875 papers received by the VJAS. The papers are being sent to the readers today.

Visiting Scientist's Program - Jack Cranford

Absent

AAAS - Representative Ertle Thompson

Ertle Thompson reported on the meetings of the AAAS Affiliates and the NAAS. The incoming President of the AAAS is interested in promoting closer relationships with the affiliates. The attached report includes a list of topics that will be discussed further by the members of the NAAS.

Science Museum of Virginia - Trustee Vera Remsburg

The 25th Anniversary of the Science Museum will be celebrated this year. The General Assembly created the Science Museum July 1, 1970. Vera announced that the Chesapeake Bay week at the Museum will be March 13-17.

As of July 1, 1996, Vera will no longer be a member of the Trustee Board of the Museum. The Council needs to nominate two members of the Academy for this position. Walter Witchey will receive the nominations and make a recommendation to the Governor who in turn appoints the new Trustee. We will need to have two nominees by the May meeting. Please send the names of nominees to Elsa Falls.

Vera also reported on the VJAS Distinguished Service Awards. She has a list of the recipients for the years between 1968 and 1980. The information on the recipients after 1980 is not available from the Archives. Anyone who can fill in the missing names, please contact her as soon as possible.

Jeffress and Gwathmey Memorial Trust Allocation committee - Richard Brandt

Richard Brandt will give a report at the Friday Council meeting at VMI.

VAST - Maurice Lynch

Absent

VSLA - Tom Teates

Absent

STANDING COMMITTEE REPORTS

Archives Committee - Golde I. Holtzman

No report

Awards Committee - Carolyn Conway

Student Awards will be given at the 1995 Annual Meeting. The Call for Papers for the meeting included an announcement concerning the Best Student Paper Awards. Guidelines were sent to all section secretaries.

Two nominations for fellows were submitted by the October 1st deadline. The Awards Committee has not completed its review of this information. Therefore, appropriate recommendations will be submitted to the Council in May.

Constitution and Bylaws - Co-chairs Michael L. Bass and Gerald R. Taylor

No report

Environment - J.J. Murray

In accordance with the resolution passed by Council at its meeting in November, the Committee has arranged to hold a session at the annual meeting in May. In conjunction with the Environmental Science Section, the Committee will invite representatives of colleges and universities to report on activities at their institutions that address the objectives of the Talloires Declaration of the World Watch Institute. The session will be held on Friday morning at 9:00.

Finance and Endowment - Co-Chairs Arthur w. Burke, Jr. and Paul J. Homsher

No report other than on the actions taken today - \$350 has been allocated for reprinting the membership brochures and \$500 has been allocated for attendance at the Virginia Outstanding Scientist and Industrialist Awards Reception and Banquet.

Fund Raising - James O'Brien

Jim O'Brien distributed a report from the Fund Raising Committee and a document entitled "VAS Fund Raising Campaign, Phase I: Internal/Membership" (attached). Following a discussion of these documents, Jim O'Brien moved the five motions listed on the third page of the report. These motions were seconded by Paul Homsher.

Gerald Taylor made a motion to table the five motions until they could be reviewed by the Executive Committee.

Move that the Executive Committee make a report to Council at the May meeting on the action taken on each of these motions.

The motion passed unanimously.

Junior Academy of Science - Don Cottingham

Elsa Falls reported that a pilot program for regionalization will take place in the Danville area prior to the 1996 meeting.

Long-Range Planning - Richard B. Brandt

Recommend that the President have the Chair look at the meetings for the year 2000 and beyond.

Membership - Scott H. Newton and John P. Morgan

Absent

Nominations and Elections Committee - Gerald Taylor

1995 Candidates for Academy Offices

President-Elect: R. Dean Decker
Department of Biology
University of Richmond

Vice President: Carolyn M. Conway
Department of Biology
Virginia Commonwealth University

Secretary: Joseph W. Rudmin
Physics Department
James Madison University

Treasurer: Gregory C. Cook
Tidewater Community College

Publications Committee

Virginia Journal of Science, Editor James H. Martin

Requested that quality papers be submitted for publication in the Journal.

Virginia Scientist, Editor Gregory C. Cook

Absent

Research - Judy H. Niehaus

Announced that two Horsely Research Grants have been awarded and that one paper has been submitted for the Horsely Paper Award.

Science Advisory - William L. Dewey and Ernest R. Stout

Absent

Science Education - Thomas G. Teates and Maurice P. Lynch

Absent

Trust Committee - Rae Carpenter

Rae Carpenter presented a report that described the current holdings of the Academy. The value of all of the trust fund investments increased 4% in 1994. He also included a breakdown of the Senior and Junior Academy Awards.

Paul Homshire praised Rae for his work to improve the status of the trust funds and made the following motion:

That Rae Carpenter receive acclamation for the work he has done on the Trust Committee.

This motion was unanimously approved.

Virginia Flora - Marion Lobstein

A questionnaire concerning plant identification has been sent to members of the Botany section and to educational organizations. An E-mail bulletin board is being established.

SPECIAL COMMITTEE REPORTS

Futures Committee - Rae Carpenter

The following motion was presented to Council:

The Executive Committee recommends to Council that the President appoint a committee to review the agreement and performance thereof between the VAS and Virginia Science Museum regarding the VJAS Associate Director position. This meeting should be held in early summer.

This motion was passed unanimously.

Public Affairs - Ralph Eckerlin and Marion Lobstein

VAS membership pamphlets will be available at the upcoming meeting of the Virginia Community Colleges' Biology Faculty.

The proposed regulations of the US Fish and Wildlife Commission were reviewed by the Biology Section.

75th Anniversary Committee - Golde Holtzman

Golde Holtzman thanked Jim O'Brien for his work on designing a logo for the 75th Anniversary. Charlotte Webb is making good progress on the history of the Academy.

VJAS Director Search - Carolyn Conway and Gerald Taylor

Gerald Taylor reported that no one is in place yet for taking over as Director of the VJAS and Don will continue in this position. A possible candidate may be available in about 3 1/2 years.

SECTION REPRESENTATIVE'S REPORTS

Aeronautical and Aerospace Science - Fred Lutze

Absent

Agriculture, Forestry and Aquaculture - Scott Newton

Absent

Archaeology - J. Mark Wittkofski

Absent

Astronomy, Mathematics, and Physics - Kenneth C. Jacobs

The section is healthy and may have to hold a Friday morning session.

Biology - Carolyn M. Conway

The Biology Section has received a number of papers including 20 student papers.

A Letter of Comment was sent to the USFWS regarding the proposed regulations for importing and exporting scientific specimens. Comments were coordinated with those of the Association of Systematic Collections. Several individuals also responded individually. The volume of response was such that the comment period was extended 30 days and USFWS is reconsidering the new regulations.

Biomedical and General Engineering - Eleni Achilleos and Penny Pagona

Absent

Botany - Marion Lobstein

Not as many papers as last year but expected to have a good day on Thursday.

Chemistry - George Mushrush

Absent

Computer Science - Robert Willis

Absent

Education - Thomas Teates

Absent

Environmental Science - Michael L. Bass

Jim Murray reported that they had many papers and will run a Friday session.

Geography - Jack Gentile

Absent

Geology - David Harbor

The Geology section will hold a one day session.

Materials Science - Kenneth Lawless

Absent

Medical Sciences - Sandra Welch

Absent

Microbiology and Molecular Biology - Frances Macrina

Absent

Psychology - Robert A. Berquest

We received 15 papers by the due date and another 7 arrived a day later. Eight posters were also submitted. George Jones notified, by letter, chairs and Department Heads of Psychology at all appropriate colleges and universities of the opportunity to present papers and posters at the May meeting. Things are progressing well for the May meeting.

Statistics -John Morgan

Golde Holtzman reported that they had received an average number of papers.

OLD BUSINESS

Ralph Eckerlin requested \$1000 for the Appalachians Biogeography Symposium. Over 40 papers will be presented and the participants will be paying their own expenses. The largest expense associated with the symposium will be the publication of the proceedings.

The following motion was made:

That a donation of \$1000 be given to support the Appalachian Biogeography Symposium.

At this point the discussion centered around the existence of precedents for this type of donation. Golde Holtzman mentioned that funds were given as seed money for projects and that the Academy is acknowledged as a sponsor. Rae Carpenter stated that the Academy sponsors symposium at its own meetings.

The motion passed unanimously.

NEW BUSINESS

Marion Lobstein spoke about her concern that changes are taking place in recognizing the importance of labs in science education. She indicated that at Community Colleges laboratory teaching is not included in the contact hours for the faculty member.

A number of members of the Council expressed their concerns that the laboratories are being cut to save money. Jim Murray mentioned that computer simulations are being used to teach labs and at JMU the Anatomy courses are taught using computers. Also, Biology labs have been eliminated from the intro courses. After hearing about a number of these situations, the feeling was that the VAS must speak out and try to influence the policy.

It was recommended that an open discussion of this issue take place at the Academy Conference and that a resolution be prepared that can be acted on at that meeting. Carolyn Conway, Paul Homshure and Marion Lobstein volunteered to prepare the resolution.

The meeting was adjourned at 4:35.

BYLAWS OF THE VIRGINIA ACADEMY OF SCIENCE

Recommendation from the Constitution and Bylaws Committee that was submitted to VAS Council, May 26, 1995 and approved by Council for submission to membership.

**CURRENT WORDING OF
ARTICLE I: TYPES OF MEMBERSHIP**

- Section 3. Life members shall be individuals who elect to pay to the Academy the sum of three hundred dollars (\$300.00) and thereby become exempt from further payment of dues.
- Section 4. Patrons shall be those persons who have given to theis organization the sum of one thousand dollars (\$1000.00) or its equivalent in property. They shall have all the rights and privileges of Regular Members and shall be exempt from dues. An institution may also become a Patron by meeting the above requirement. Its representative shall have all the rights and privileges of regular members.

**APPROVED CHANGE IN WORDING OF
ARTICLE I: TYPES OF MEMBERSHIP**

- Section 3. Life members shall be individuals who elect to pay to the Academy the sum of five hundred dollars (\$500.00) and thereby become exempt from further payment of dues.
- Section 4. Patrons shall be those persons who have given to theis organization the sum of one thousand dollars (\$1000.00) or its equivalent in property. They shall have all the rights and privileges of membership for one year. An institution may also become a Patron by meeting the above requirement. Its representative shall have all the rights and privileges of regular members.

The following resolution was approved unanimously by both the Virginia Academy of Science Council (the organization's governing board) on May 24, 1995 and by the Academy Conference, on May 25, 1995 at the VAS Annual Meeting at VMI.

IMPORTANCE OF LABORATORY IN SCIENCE EDUCATION

In association with other professional scientific groups and organizations, the Virginia Academy of Science strongly supports the laboratory experience as an integral part of science education at all levels. Science is a study of natural phenomena and requires a laboratory component which permits and encourages discovery and creativity. Science faculty welcome electronic technology as a potentially effective tool to expand and to enhance instruction. However, it can neither duplicate nor replace learning experiences afforded to students through hands-on lab and field activities. These hands-on laboratory and field experiences:

engage students in open-ended investigative processes, using scientific problem solving

provide application of information students have heard and seen in lecture, thereby reinforcing and clarifying scientific principles and concepts

involve multiple senses in three-dimensional rather than two-dimensional learning experiences important for greater retention of concepts and for accommodation of different leaning styles

stimulate students to understand the nature of science including its unpredictability and complexity

provide opportunities to engage in collaborative work and to model scientific attitudes and behavior

develop mastery of techniques and skills needed for potential science, engineering, and technology majors

ensure science course transferability to four-year schools as well as to graduate and professional schools within and outside of Virginia

In summary, the knowledge gained from science courses with a strong laboratory component enables students to understand in more practical and concrete ways their own physical makeup, the functioning of the natural world around them, environmental issues, etc. It is only by maintaining hands-on lab experiences that the brightest and most promising potential science majors will be stimulated

and not turned off by lecture only approaches to science. These lab courses may offer many students their only opportunity to experience a science laboratory environment. These same students as potential voters, parents, teachers, legislators, developers, and land use planners benefit from a well-rounded educational experience, including laboratory experience, in making sound decisions for the future of Virginia.

NOTES

NOTES

MEMBERSHIP

Membership in the Academy is organized into sections representing various scientific disciplines as follows:

1. Agriculture, Forestry and Aquaculture
2. Astronomy, Mathematics and Physics
3. Microbiology and Molecular Biology
4. Biology
5. Chemistry
6. Materials Sciences
7. Biomedical and General Engineering
8. Geology
9. Medical Sciences
10. Psychology
11. Education
12. Statistics
13. Aeronautical and Aerospace Sciences
14. Botany
15. Environmental Science
16. Archaeology
17. Computer Science
18. Geography
19. Natural History & Biodiversity

Annual Membership Dues - Includes subscription to
Virginia Journal of Science

Student	\$ 10.00
Regular - Individual	25.00
Contributing - Individual	30.00
Sustaining - Individual	50.00
Life - Individual	300.00
Sustaining - Institution	100.00
Business - Regular	100.00
Business - Contributing	300.00
Business - Sustaining	500.00
Patron	1000.00



VIRGINIA ACADEMY OF SCIENCE

APPLICATION FOR MEMBERSHIP

Date _____ Name (Please Print) _____

Phone (_____) _____ E-mail _____ FAX(_____) _____

Address _____

City _____ State _____ Zip _____

Institution or Business _____

Position — Title _____

Fields of Interest — Section No.(s) _____ First No. indicates major interest

Class of Membership Desired _____

Contacted by: _____

Make check payable to Virginia Academy of Science and send to: VAS, Science Museum of Virginia, 2500 W. Broad St., Richmond, VA 23220-2054.

Instructions to Authors

All manuscripts and correspondence should be addressed to the Editor. The Virginia Journal of Science welcomes for consideration original articles and short notes in the various disciplines of engineering and science. Cross-disciplinary papers dealing with advancements in science and technology and the impact of these on man and society are particularly welcome. Submission of an article implies that the article has not been published elsewhere while under consideration by the Journal.

Three complete copies of each manuscript and figures are required. It is also suggested that authors include a 5.25 diskette in IBM compatible format containing a text file (ASCII) of the manuscript. Original figures need not be sent at this time. Authors should submit names of three potential reviewers. All manuscripts must be double-spaced. **Do not use special effects such as bold or large print.**

The title, author's name, affiliation, and address should be placed on a cover page. An abstract (not to exceed 200 words) summarizing the text, particularly the results and conclusions, is required. The text should follow the general format used by professional journals in the author's discipline. Literature cited in the text should follow the name-year format: (McCaffrey and Dueser, 1990) or (Williams et al., 1990). In the Literature Cited section at the end of the article, each reference should include the full name of the author(s), year, title of article, title of journal (using standard abbreviations), volume number and first and last page of the article. For a book, include author(s), year, title, pages or number of pages, publisher and city of publication. Examples:

McCaffrey, Cheryl A. and Raymond D. Dueser. 1990. Plant associations of the Virginia barrier islands. *Va. J. Sci.* 41:282-299.

Spry, A. 1969. *Metamorphic Textures*. Pergamon Press, New York. 350 pp.

Each figure and table should be mentioned specifically in the text. All tables, figures and figure legends should be on a separate pages at the end of the text.

Multiple author papers are required to have a statement in the acknowledgements indicating the participation and contribution of each author.

After revision and final acceptance of an article, the author will be required to furnish two error-free copies of the manuscript: 1) typed copy, single spaced, with tables and figure captions at the end of the document, and one set of original figures, each identified on the back by figure number and author's name; 2) a 5.25 diskette in an IBM compatible format containing the text file, tables and figure legends.

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THE VIRGINIA JOURNAL OF SCIENCE

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ABSTRACTS OF PAPERS

73rd Annual Meeting of the Virginia Academy of Science
May 23-26, 1995, Virginia Military Institute
Lexington, VA

Aeronautical and Aerospace Sciences (*No Abstracts Submitted*)

Agriculture, Forestry and Aquaculture Science

EFFECT OF VARIATION IN MILKING METHOD, TEAT MEASUREMENTS, AND DAY OF LACTATION ON SOW MILK COMPOSITION AND YIELD. C. H. Aardema, B. L. Williams*, A. S. Garst* and F. C. Gwazdauskas. Dept. Dairy Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061-0315. Milking methods were investigated to determine effects on porcine milk composition and yield. Sows were induced to letdown milk with exogenous oxytocin and milked by machine with: pulsation rates of 60 (50:50 milk:rest) and 150 (23:78) pulses/min, teat cup sizes of 12, 14, and 15 mm i.d., teat cups weights of 45, 70, 95, and 120 g, and piglet removal of 60 min or no removal prior to milking throughout lactation. Oxytocin resulted in a somatic cell count of 3.48×10^6 /ml milk for i.v. administration and 7.53×10^6 for i.m. injection. Protein increased from d 10 (3.5%) to d 40 (6.3%) and was highest for the first milking of the day (6.2%). A pulsation rate of 150 resulted in 29.5 ml milk per teat per milking, whereas 60 per min yielded 24.3 ml milk per teat per milking. A teat cup size of 15 mm led to the peak milk yield (28.9 ml). Teat cup weight affected milk yield with the highest yield from the 95 g cup (31.7 ml) while 45, 70, and 120 g cups yielded less (20.7, 26.6, and 28.6 ml). Yield was increased with removal of piglets for 1 h (31.5 ml) compared to no piglet removal (22.3 ml). Route of oxytocin administration affected milk yield with a higher yield for i.v. (34.4 ml per teat per milking) than for i.m. injection (19.4 ml). These results show that milk yield can be optimized by milking machine modifications and piglet removal.

SUSTAINABLE MANAGEMENT OF FOREST ECOSYSTEMS USING SYSTEM DYNAMICS MODELING. Samuel H. Austin, Forest Hydrologist, Virginia Department of Forestry, P.O. Box 3758, Charlottesville, Va. 22903. The forests of the earth are solar collectors. Energy from the sun is delayed by forests and transformed into richly diverse states of plant and animal (ecosystem) organization. No one has absolute knowledge of all forest processes. System dynamics modeling aids sustainable management of forest ecosystems by tracing the links, delays and feedback associations in these dynamic, non-linear, feedback systems. Embedded in the systems paradigm is the notion that complex, non-linear, dynamic systems may be effectively managed using relatively few controls. A model is presented that maps the future consequences of forest management decisions made using three silvicultural controls: rate of timber harvest, size of harvest opening, and choice of regenerated tree species. The model shows that forest management decisions are temporally and spatially interrelated, and that complex forest ecosystems may be effectively managed and sustained, or harmed, using various combinations of just three types of intervention.

BREED DIFFERENCES IN BREEDING SOUNDNESS EXAMINATION TESTS IN MEAT-TYPE MALE GOATS. Kori S. Baker and S. Willeus, Agricultural Res. Station, Va. State Univ., Petersburg, Va. 23806. Breeding soundness examination standards, although common for bulls and rams, have not been well defined for the goat. This project evaluated scrotal circumference (SC), reaction time and ejaculate characteristics in bucks of the Myotonic (M), Nubian (N), Pygmy (P) and Spanish (S) breeds ($n=5$ /breed). Reaction time was measured as the period bucks required to mount one of two estrus-induced ovariectomized does following entry into a test pen. Semen was collected via electroejaculation. Ejaculate volume, wave motion and individual motility were recorded and samples were stained (live/dead) and fixed (concentration/morphology) for further analysis. Data were analyzed using analysis of variance with breed as variable and age as covariate. Body weight (WT) and SC differed ($P<0.05$) between breeds, ranging from 45.0 kg and 22.7 cm in S to 22.9 kg and 20.1 cm in P, respectively. In contrast, SC:WT ratio was higher ($P<0.01$) in P (0.406) than in the other breeds (0.232-0.272). Reaction time was similar in M, P and S (20-26 sec), but N failed ($P<0.01$) to mount within the allotted test time (5 min). There were no breed differences for % motile, live and normal spermatozoa and wave motion score. Breeds differed ($P<0.05$) in ejaculate volume (0.74-1.10 ml), but not sperm concentration (0.43-1.37x10⁹/ml) and total sperm in ejaculate (0.48-1.53x10⁹). Age affected ($P<0.05$) WT, SC, SC:WT, sperm concentration and total sperm in ejaculate. There were significant ($P<0.05$) breed x age interactions for SC, ejaculate volume, sperm concentration and total sperm in ejaculate. These data indicate that the smaller mature body size of P was not associated with a proportionally smaller scrotal circumference measurement. Furthermore, breed and age effects need to be taken into consideration when developing breeding soundness examination standards for goats.

KENAF PRODUCTION IN VIRGINIA. Harbans L. Bhardwaj and M. Rangappa, Agricultural Research Station, Virginia State University, Petersburg, VA 23806 & C.L. Webber, III, USDA-ARS, Lane, OK 74555.

The United States imports two-third of its newsprint at an annual cost of about \$4.5 billion. Kenaf (*Hibiscus cannabinus* L.), a relative of cotton, okra, and hollyhock, can be turned into pulp for newsprint with lower energy and bleaching requirements than those for pine trees. The objective of kenaf research under the new crops program of Virginia State University is to evaluate feasibility of kenaf production in Virginia, determine yield potential, and develop alternative uses to sustain the crop until its use as a domestic source of pulp becomes established. The dry matter yields of 7 kenaf varieties during 1992, 1993, and 1994 varied from about 6 to 12 metric tons per hectare, respectively at 70 and 126 days after planting. This yield level compares favorably with yields reported from Mississippi, Texas and other Southern states. Possibility of multiple-harvests, desirable nutritional quality (crude protein content of about 15% at 70 days after planting), and satisfactory consumption of chopped kenaf plants by goats indicate suitability of kenaf as a forage for livestock. These results indicate that kenaf can be easily produced in Virginia. The use of kenaf as a summer forage for livestock also has considerable potential.

BROOMRAPE (OROBANCHE spp.): BOTANICAL CURIOSITY OR THREAT TO VIRGINIA. Chester L. Foy, Dept. of Plant Pathol., Physiol. & Weed Sci., Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061. Broomrapes are phanerogamic holoparasites which attack the roots of numerous broadleaved host plants, including major crops in the Solanaceae, Fabaceae, Compositae, and Umbelliferae families. Some species of broomrape produce showy flowers; others are less conspicuous. In northern and western Europe, *Orobanche* spp. occur sparsely and are preserved as botanical curiosities. However, the genus is a devastating noxious weed in semi-arid and some temperate regions of the world. Three species, *O. ramosa*, *O. minor*, and *O. luteoviridis* exist in the USA. Three of the most devastating species in the world, *O. aegyptiaca*, *O. ramosa*, and *O. crenata* have the potential to parasitize and cause severe yield loss in tomato, tobacco, peanut, alfalfa, and soybean. All means of control used against broomrape have limitations either in terms of effectiveness or expense. A four-year US AID trinational (Egypt-Israel-USA) project titled Multipronged Approaches to Eliminating Crop Devastation by Parasitic Weeds is now in its second year. The project is divided into three approaches, agronomic, biocontrol, and biotechnological. Research at VPI & SU involves: testing nitrogen fertilizers and germination stimulants; analyzing enzymes, amino acids, and proteins in host plants and broomrapes; studying germination, haustorium formation, attachment, and early development of broomrape on various host and trap crops; and DNA fingerprinting of *O. minor* from Virginia, the Carolinas, and Georgia. Representative research highlights will be presented.

TRENDS IN RED MEAT SLAUGHTER IN THE US. T.A. Gipson, Agricultural Res. Station, Va. State Univ., Petersburg, VA 23806 and S. R. Rein, Dept. of Math. Sci., Va. Commonwealth Univ., Richmond, VA 23284-2014. Weekly slaughter data on cattle, hogs, sheep, goats and horses were obtained from the USDA National Agricultural Statistical Service and analyzed for time trends. The dataset covered the 15-year period of 1980 through 1994 and only for the aforementioned species slaughtered at federally inspected plants. Trends for the number of cattle, hogs, sheep and horses slaughtered at federally inspected slaughter facilities tend to be cyclical. In recent years, cattle and hog numbers seem to be increasing; however, sheep and horse numbers seem to be decreasing. The trend for the number of goats slaughtered at federally inspected slaughter facilities tends to be linear and increasing over this time period.

RESULTS OF A SURVEY OF VIRGINIA GOAT PRODUCERS. T.A. Gipson, Agricultural Res. Station, Va. State Univ., Petersburg, VA 23806. A survey was developed and distributed to goat producers in the commonwealth to establish a profile of the management practices of the different goat operations. A total of 66 goat producers responded to the survey. The number of producers owning a single breed of goats versus those who owned two or more breeds were nearly equal (52% vs. 48%, respectively). Nubians were the most popular breed with 45% of the respondents stating that they owned that breed. Second popular were Pygmies with 24% of the respondents owning this breed which is kept as pets and not for production purposes. The average herd size is small with 55% of the respondents owing fewer than 15 animals. Twenty-three percent (23%) owned 16 to 30 animals, 11% owned 31 to 50 animals, 3% owned 51-100 animals and 8% had more than 100 animals in their herd. Goat producers are long on experience with 37% responding that they have owned goats for more than ten years. Twenty-three percent (24%) have owned goats for between six and ten years, 21% owned goats for between three and five years and 18% had owned goats less than three years. The vast majority (76%) of goat producers are not full-time farmers and keep goats or other livestock as a sideline. Twenty-six percent (26%) of the respondents stated that they only kept goats. Among those that kept other livestock besides goats, poultry was the most popular with 35% of the respondents. Cattle were second at 27%. Twenty-three percent (23%) of the respondents also raised horses or sheep and 5% raised rabbits or swine. Of the goat producer that did raise other livestock, 74% co-grazed their goats with the other livestock. Woven wire fencing was the most popular type of fencing used by goat producers with 62% of the respondents using it. Second was high tensile electric or simpler electric fencing used (38%). Barbed wire was used by only 8% of the producers. Goat producers in the commonwealth utilize many different management practices.

PERIPARTURIENT RISE IN FECAL EGG COUNTS IN GOATS. T.A. Gipson, Agricultural Res. Station, Va. State Univ., Petersburg, VA 23806 and A. M. Zajac*, VA-MD Regional Col. of Veterinary Medicine, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. Increased pasture contamination by parasitic nematode eggs associated with parturition is an important management consideration in the control of gastrointestinal parasites in sheep. It has not been well established if goats also have a corresponding rise in nematode egg output at or near kidding, especially in meat goats in the Mid-Atlantic region. The objective of this study was to monitor pregnant and non-pregnant does for any rise in nematode egg output. Fecal samples were taken weekly from twenty-two pregnant and fifteen non-pregnant Spanish meat goats from approximately six weeks prepartum to four weeks post-partum. Fecal samples were analyzed using the Modified McMaster technique to determine levels of trichostrongyle eggs and coccidia oocysts per gram of feces. Counts were transformed using a log(count+1) transformation and analyzed as repeated measures using a split-plot design. The linear and quadratic effects of time were evaluated using covariate analysis. For trichostrongyles and for coccidia, there was no significant ($p < .05$) difference in fecal egg counts of pregnant versus non-pregnant does. The linear and quadratic effects of time were significant ($p < .05$); indicating an increase and then a resulting decrease of fecal egg counts over the time period of this study. Fecal egg counts of pregnant does were statistically analyzed for time effects about time of parturition. For trichostrongyles, a significant linear and quadratic effect exists; however, none were observed for coccidia. This study suggests that a rise in fecal egg counts does exist in goats; however, it was not associated with parturition. Previous studies in this area have shown a definite pregnancy status by nutritional status interaction. The does in this study were maintained on improved natural pasture and supplemented with grain. Additional studies are needed to investigate the periparturient rise phenomenon in meat goats further.

CAN TRAP CROPS PREVENT HARLEQUIN BUG DAMAGE IN CRUCIFEROUS CROPS? Scott W. Ludwig & Loke T. Kok*, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061. The harlequin bug, *Murgantia histrionica* Hahn, is an exotic pest of cruciferous crops in the southern regions of the United States. It sucks juices from the stems and leaves of plants and was considered the most destructive insect pest of cabbage and related crops before the advent of synthetic insecticides. Our hypothesis is that trap crops can be used to prevent the harlequin bug from building up destructive populations on broccoli when insecticides are not used to suppress them. The use of trap crops in preventing harlequin bug damage has not been field tested. Thus, we planted broccoli, mustard and rape as trap crops of broccoli during 1994. In both the spring and fall plantings, almost 100% of the harlequin bugs were on the trap crops which prevented infestation of broccoli. This shows that trap crops can prevent harlequin bug damage of broccoli. The study will be repeated in 1995 to see whether this will be confirmed.

EFFECTS OF FOOD PROCESSING ON THE NUTRITIONAL QUALITY OF LEGUMES. III. LENTIL (*lens esculentum*). Ali I. Mohamed, Agricultural Research Station, Virginia State University, Petersburg, Va 23806. Lentil (*Lens esculentum*) is one of the oldest legume crops. The preparation of lentil soup is depicted in a fresco of the time of Rameses III (1200 B.C.). Lentil is a staple source of protein, calories, and minerals of vegetarian diets in many countries and holds promise as a future food for the Western world. In this study, effects of dry dehulling processes, soaking, and cooking on the nutritional quality of lentil were investigated. There were no significant changes in amino acids by dry dehulling. Dehulling was associated with a significant increase in total protein and total hydrolyzable carbohydrates (26 to 28% and 62 to 69% respectively), phytic acid (172 to 212), and reducing and non-reducing sugars. Highly significant reductions in crude fiber (4.0% to 0.9%), tannins (117 to 85), and total phenols were observed. Protein and carbohydrate digestibility were significantly increased by dehulling, from 74 to 77%, and 45 to 47%, respectively. Soaking and cooking decreased protein and hydrolyzable carbohydrates due to leaching. Cooking and soaking in 0.05N NaOH resulted in a significant increase in digestibility of protein and carbohydrates from 74 to 95 and 21 to 86% respectively. It appears that anti-nutritional factors other than tannins and phenolics are present in lentil and were reduced by dehulling, soaking, and cooking.

A NEW METHOD TO LABEL CHOLESTEROL AND ITS APPLICATION TO STUDY CHOLESTEROL ABSORPTION IN NORMAL AND HYPERCHOLESTOLEMIC ANIMALS. Ali I. Mohamed, Agricultural Research, Virginia State University, Petersburg, VA 23806. Iodocholesterol was prepared using iodine monochloride tagged with Iodine¹³¹. The iodo¹³¹ cholesterol was used to study the absorption and distribution of cholesterol in various tissues of hypercholesterolemic and normal rats. A single dose of this compound was administered orally to normal and treated rats and the specific activity in the different tissues was measured after 24, 48, and 168 hr after administration of the dose. The data showed that hypercholesterolemia resulted in a significant alteration in the absorption and distribution of radiolabeled cholesterol in various tissues of the normal and diseased rats. Aorta had the highest specific activity in through the study in the diseased rats than other organs. Thyroid gland accumulated less iodinated cholesterol in hypercholesterolemic animals which may reflect a hyperthyroidism state due to the presence of methylthiouracil in atherogenic solution. The distribution of radioactivity in tissues after oral administration of iodocholesterol was used to evaluate the potential use of this compound as photoscanning agents. The distribution ratios of radioactivity in aorta : lung and aorta : liver were considered low for possible use as a photoscanning agent for aorta. However, this compound could be tested for photoscanning for other diseases such as cancer.

EARLY PREGNANCY DETERMINATION IN MEAT-TYPE GOATS USING TRANSRECTAL AND ABDOMINAL ULTRASONOGRAPHY. G.A. Moore^{1*} and S. Wildeus², ¹College of Vet. Medicine, Virginia Tech, Blacksburg, VA 24061 and ²Agricultural Res. Station, Va. State Univ., Petersburg, Va. 23806. The use of pregnancy diagnosis by real-time ultrasound has become a useful tool in livestock management. The current project evaluated the efficacy of transrectal (TR) and transabdominal (TA) ultrasonography using a 5 MHZ linear array probe (Pie Medical, model 480) for the detection of pregnancy at three stages post mating in three breeds of meat goats of varying mature size (Myotonic, Pygmy, Spanish). Does (n=60) used in the study were either bred to a synchronized estrus or the subsequent cycle following synchronization. Pregnancy diagnosis was performed at 25-30 (PD1), 50 (PD2) and 75 (PD3) days post mating. Animals were scanned standing for both modes of diagnosing, using a custom handle for probe manipulation transrectally. Does were classified as pregnant, open or 'no diagnosis' and variables were analyzed using a categorical models procedures. The overall frequency of 'no diagnosis' was 6.1% and tended to be affected by mode ($P=0.12$) and time ($P=0.11$) of scanning, but not by breed, age or body weight. A differential diagnosis between TR and TA was obtained in 23.0% of cases. Differential diagnosis was affected by breed ($P<0.05$), ranging from 4.5% in Pygmy to 32.7% in Spanish does. There was a tendency ($P=0.11$) for differential diagnosis to be affected by time of scanning and at PD1 this was associated exclusively with underestimating the number of pregnant does using TA, whereas at PD3 TR always underestimated the number of pregnant does. These data demonstrate that pregnancy diagnosis using linear array ultrasound can be affected by breed in meat-type goats and that transrectal diagnosis is possible as early as 25 to 30 days post mating.

GERMINATION RESPONSE OF BROOMRAPE (*OROBANCHE* spp.) TO MOISTURE STRESS AND NUTRIENTS. Vijay K. Nandula and Chester L. Foy, Dept. of Plant Pathology, Physiology, and Weed Science, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. Broomrapes, belonging to the family Orobanchaceae are phanerogamic holo-parasites lacking chlorophyll. An experiment was conducted in vitro to evaluate the effect of various forms of nitrogen fertilizer on germination and radicle length of four broomrape species (*O. aegyptiaca*, *O. cernua*, *O. crenata*, and *O. ramosa*). Nitrogen in the form of NO_3^- , NH_4^+ , and urea was applied to seeds of broomrape in presence of a germination stimulant. Germination of most of the species tested was significantly less with urea and NH_4^+ compared to NO_3^- . In the same study, the influence of cations like Na^+ , Ca^+ , and K^+ had a positive influence on NO_3^- in enhancing the germination of *O. aegyptiaca*, whereas NH_4^+ gave a lower response. A different experiment was conducted to study the effect of moisture stress, induced with polyethylene glycol, on germination of the four broomrape species mentioned earlier. In general, germination percentage was highest at lower osmotic potentials and gradually declined with all the species except *O. crenata* recording negligible results at -8 bars. Presence of nitrogen and cations, osmotic potential of soil, and presence of a suitable host root, all collectively determine the potential for broomrape attack.

AN OVERVIEW OF THE RAINBOW TROUT INDUSTRY IN VIRGINIA. Scott H. Newton, Virginia State University, Petersburg, VA 23806, Jimmy A. Lawson, Virginia Agriculture Statistics Service, Richmond, VA 23209, and Bryan P. Plemmons, Castaline Trout Farms, Goshen, VA 24439. Rainbow trout (*Oncorhynchus mykiss*) culture is the oldest and most established freshwater aquaculture industry in Virginia and in the United States. Since the early 1950s, trouts have been cultured in the mountains of Virginia using existing springs and streams. Since 1990, they also have been reared in cages and farm ponds in the Piedmont and Coastal regions, from fall to spring when water temperatures are suitable for their survival and growth. Rainbow trout is the major species of freshwater fish grown in Virginia. Brook (*Salvelinus fontinalis*), brown (*Salmo trutta*), and golden trout (a genetic color variation of the rainbow trout), are the other species being reared in the State. Nationally, Virginia ranks sixth in total pounds produced and is the third largest trout producing state on the East coast. Since 1988, annual sales have been slightly over \$2 million for approximately one million pounds of fish. While most regional trout markets are nearly saturated, niche markets are available for specialty products and stocking live trout in recreational fee fishing ponds.

RESPONSE OF THREE MEAT-TYPE BREEDS OF GOATS TO TWO METHODS OF ESTRUS SYNCHRONIZATION. S. Wildes¹ and G.A. Moore^{2*}, ¹Agricultural Res. Station, Va. State Univ., Petersburg, Va. 23806 and ²College of Vet. Medicine, Virginia Tech, Blacksburg, VA 24061. Estrus synchronization in small ruminants is a valuable reproductive technique to control the mating season and facilitate out-of-season breeding, artificial insemination and embryo transfer. However, no synchronization systems are currently commercially available for sheep and goats in the U.S. This experiment evaluated the estrus and conception rate in 3 meat-type goat breeds (Spanish - S, n=31; Myotonic - M, n=29; and Pygmy - P, n=13) using either 2 mg norgestomet (1/3 Synchro-Mate-B® cattle ear implant - NOR) or 500 mg progesterone (custom-made vaginal pessary - PRO) without gonadotropin co-treatment. Average doe age (2.8 yrs) was similar for all breeds, with body weights ranging from 16.5 kg in P to 28.3 and 26.2 kg in S and M, respectively. Does were implanted for a 12 d period at the end of the natural breeding season (December/January). Following implant removal does were observed for estrus for 5 days and hand mated to different sires of like breeds. At 35 and 50 d post implant removal conception was determined via ultrasonography. Retention of NOR implants was higher than of PRO pessaries (100% vs. 94.1%; P=0.097), caused specifically by the loss of PRO pessaries in P (33%). The estrus response and time from implant removal to estrus was similar for NOR (79.5%, 50.3 hrs) and PRO (78.1%, 54.9 hrs), regardless of breed. Overall conception rate to the synchronized estrus was 57.1%, but was lower (P<0.05) in P-PRO (0%) compared to S-PRO (72.7%) and M-PRO (70.0%). These data suggest that 1) a third of a Synchro-Mate-B® implant is sufficient for estrus synchronization in meat-type goats and 2) vaginal pessaries perform unsatisfactory in Pygmy does.

Archaeology

"OBSERVATION, PARTICIPATION, EDUCATION:" WORKING TO EXPAND THE RELEVANCE OF AFRICAN AMERICAN SITES. Anna S. Agbe-Davies, Dept. of Archaeological Res., The Colonial Williamsburg Fndn., Williamsburg, VA 23185. As archaeologists, we are responsible not only for the excavation of sites and the curation of artifacts, but the dissemination of findings to our colleagues and to the general public. Conferences such as this one help us fulfill our obligation to one another, but how do we share our discoveries with the public? This paper describes public involvement at several African American archaeological sites and discusses possibilities for future cooperation, both among professionals, and between archaeologists and their lay audience.

PREHISTORIC ARCHAEOLOGY AT THE MULBERRY ISLAND SITE, RICHMOND COUNTY, VIRGINIA. Courtney Anderson, Dept. of Historic Preservation, Mary Washington College, Fredericksburg, Va. 22401. The Mulberry Island Site (44RD81) was identified by surface collection during the 1993 cultural resource assessment survey of Richmond County, Va. by Mary Washington College. A second phase of investigation, conducted by the 1994 Mary Washington College- Stratford Hall Field School, consisted of four operations of surface collections, two transects of shovel test pits and one test unit. The resultant assemblage consists of approximately 950 prehistoric ceramic and lithic artifacts. The ceramic assemblage ranges from the Early Woodland period to the Contact period. A hearth feature within the test unit and the lithic assemblage reveal prehistoric exchange from beyond the Northern Neck and the dominance of expedient manufacture at this site. Statistical analysis of the artifact assemblage evidences 44RD81 as an ephemeral site inhabited in order to exploit marshlands from the Late Archaic period to the Contact period. (Supported by undergraduate research grant awarded by Mary Washington College.)

PROCEEDINGS

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ANALYSIS OF RECOVERED FAUNAL REMAINS FROM THE AFRICAN-AMERICAN OWNED BURRELL PHARMACY SITE (44RN256), CITY OF ROANOKE, VIRGINIA.

Michael B. Barber, Preservation Technologies, Inc., P.O. Box 921, Salem, Va. 24153. The analysis of 2,722 animal bones recovered from the midden deposit associated with the 1897 - 1917/18 Burrell Pharmacy lend insight into the foodways of an African-American population of the turn-of-the-century, urban South. The recovered fauna emphasized Bos taurus (cattle), Sus scrofa (pig), and Gallus gallus (chicken). Cuts of beef were characterized as sawn, highly regularized, and of moderate to lesser and low quality. A high frequency of teeth and cranial elements suggested either nearby butchery or the consumption of head soup/stew. Pork cuts were also of low quality including jowl and headcuts and pigs' feet. Chickens were consumed as a unit and may have been raised in the neighborhood. Few wild animals were eaten and Rattus sp. (rat) was noted as a nuisance species. On the whole, the vertebrate faunal assemblage depicts a community of low economic scale, consuming primarily lesser and low quality meats.

THE ISAAC D. BURRELL PHARMACY SITE (44RN256): AN AFRICAN-AMERICAN DRUGSTORE 1897-1917\18, CITY OF ROANOKE, VIRGINIA.

Michael F. Barber and Michael B. Barber, Preservation Technologies, Inc., P.O. Box 921, Salem, VA 24153. The Burrell Pharmacy site represents a window on the day-to-day activities and lifestyles of the black community in Roanoke at the turn-of-the-century. The excavations sampled a city block of the historic Gainsboro Community on which the Davis Hotel was situated. A number of businesses shared the building throughout the late 19th and early 20th century including groceries, restaurants, and the Burrell Pharmacy. The cultural remains investigated consisted of the pharmacy foundations and a sample of an extensive trash midden deposit. Over 27,000 artifacts were recovered with a large number relating to the drugstore era. The implications of the cultural remains are examined with an eye on the community, regional and national perspectives.

EVOLUTION, USES AND CULTURAL IMPLICATIONS OF GLASSWARE AT THE DR. ISAAC D. BURRELL PHARMACY (44RN256), AN AFRICAN-AMERICAN TURN-OF-THE-CENTURY DRUG STORE EXCAVATED IN ROANOKE, VIRGINIA. Eugene B. Barfield and Joel Hardison, Heritage Resources, George Washington and Jefferson National Forests, Roanoke, VA 24019. In 1893, upon receiving his Medical degree Dr. Isaac D. Burrell traveled to Roanoke, Virginia to start his practice. He also established a pharmacy hailed by a Richmond newspaper as "the largest and best stocked drugstore in the state owned by a colored man." Within the real but unrecognized social strata of the black community the doctor and his wife were admired and respected. Recognition from whites came only when there was trouble. Dr. Burrell's drugstore operated from 1897 until 1914 when he became gravely ill. Unable to enter local white hospitals the doctor traveled to Washington, D.C. where he died. A planned widening of one of the main streets in Gainsboro (the black community) initiated the Section 106 process leading to Phase III mitigation of the long since razed drugstore. Pharmaceutical glassware artifacts and drugs for types of illnesses are discussed as well as the lack of turn-of-the-century apothecary excavations available for comparative analysis.

A SKELETAL COMPARISON OF HUMAN REMAINS FROM TWO LATE WOODLAND SITES IN SMYTH COUNTY, VIRGINIA. Cliff Boyd and Donna Boyd, Dept. of Sociology and Anthropology, Radford Univ., Radford, VA 24142. Recent limited archaeological excavations at the Fox Site (44SM1) resulted in the recovery of the remains of seven Native American individuals. The age, sex, preservation, and incidence of pathologies for these individuals are described and are compared to the 35 individuals previously excavated from the nearby Bonham Site (44SM7). Both sites represent components of MacCord's Intermediate Culture dating to the latter portion of the Late Woodland period (ca. A.D. 1400-1600). In addition to the skeletal comparison, discussions of previous work at the Fox Site and the mortuary patterns for both Fox and Bonham are presented.

"ONE CAN NOT CALL THEM BY THE NAME OF HOUSES": THE SEARCH FOR GEORGE WASHINGTON'S UNION FARM SLAVE QUARTER. S. Curtis Breckenridge, Mount Vernon Ladies' Association, Mount Vernon, Va. 22121. In 1991 archaeologists with the Mount Vernon Ladies' Association surveyed to locate the site of buildings at George Washington's Union Farm. An outlying quarter, part of Washington's 8000 acre Mount Vernon plantation, Union Farm contained dwellings housing both African-American slaves and a White overseer. The survey was designed to yield evidence of the quarter in order to provide a comparative assemblage of African-American associated artifacts. This paper will present the results of the survey and subsequent work.

THE INDIAN ARK: ARCHAEOLOGY RESOURCE KIT. Keith T. Egloff, Dept. of Historic Resources, 221 Governor Street, Richmond, Va. 23219. The ARK brings to teacher's classroom an exciting, multidisciplinary, multisensory approach to learning about Virginia's first people. It is designed to make the job of teaching local and state history easier and more enjoyable. The kit give students a variety of ways to explore Virginia's earliest cultures through archaeology--books, drawings, maps, videos, artifact replicas, and a computer game. The enclosed Teacher's Guide presents discussion questions and projects that will deepen student's awareness of people, places, and events of the past that still influence us today. The kit can help teachers meet Standards of Learning Objectives for Social Studies, Language Arts, and Science for grades K-12. Twenty Indian ARKS are being assembled. Soon they will be available through the mail to school teachers across Virginia.

PREHISTORIC SUN CIRCLES, CEREMONIES, AND ROCKART. Wm Jack Hranicky, Archeonic Systems of Virginia, P.O. Box 11256, Alexandria, VA 22312. This paper discusses Virginia's rockart sites, namely Little Mountain (44NZ13) and Paint Lick Mountain (44TZ13), as prehistoric solar observatories. The hand and concentric ring glyphs analyzed and contrasted to other Mississippian glyphs with an emphasis on their being a symbolic priestly sign for a solar festival. The use of red ochre as a priest-associated color is discussed. The paper presents a distributional history of the ring glyph with arguments that it is a solar glyph symbol which is directly associated with solar observatories and village celebrations of the winter and summer solstices. Mesoamerican examples are discussed for origins and incorporation into the Mississippian culture. Also, the implications of post-marked sun circle or ceremonial areas on eastern village sites are discussed. The paper uses White's 1585 circle-dance drawing for reference on solar ceremonies and solar observatories.

SETTLEMENT AND SUBSISTENCE IN THE VIRGINIA PIEDMONT AND FALL ZONE: SURVEY RESULTS FROM TWO MILITARY BASES. Clifton A. Husted, William and Mary Center for Archaeological Research, Williamsburg, VA 23187. Preliminary archaeological surveys of Quantico Marine Corps Base in the Northern Fall Zone and Fort Pickett in the Southern Fall Zone of Virginia have indicated substantial differences in settlement patterning for the poorly known Woodland period between these two areas. Although physiographically very similar, the two study areas have produced widely differing temporal/functional archaeological assemblages. It is inferred that the populations of these areas responded to similar needs by the utilization of very different subsistence and settlement strategies. This also suggests differing levels of socio-political complexity and interaction with the neighboring areas.

FOLK ART, ARCHITECTURE, AND ARTIFACT: TOWARD A MATERIAL UNDERSTANDING OF ACCULTURATION IN GERMAN SETTLEMENT IN THE SHENANDOAH VALLEY OF VIRGINIA. Donald W. Linebaugh, Dept. of Anthro., College of William and Mary, Williamsburg, Va. 23185. This paper will use Pennsylvania German folk artist Lewis Miller's work as evidence for approaching problems central to understanding life in the 18th- and 19th-century American backcountry, particularly acculturation in German settlement. From a cultural history perspective, Miller's drawings provide an opportunity to glimpse brief moments in time across the landscapes of Pennsylvania and Virginia. His drawings contain highly detailed depictions of people and places throughout the Shenandoah Valley, particularly landscapes and architectural subjects. The drawings provide new evidence to test assumptions about the acculturation of Germans in Virginia, particularly when used with architectural, archaeological, and other cultural material data from the period. Because they are contemporary depictions of the architecture and landscape and were produced by and among members of an acculturative group, they offer a slightly different perspective from the previous architectural studies that utilize surviving structures in a modern post-acculturative setting.

THE ROLE OF ARCHEOLOGY IN VIRGINIA'S NATURAL HISTORY. Howard A. MacCord, Sr., 562 Rossmore Road, Richmond, VA 23225. Archeological research probes human history and adaptions over the past ten millenia. The information recovered included geologic, botanic, and zoologic evidence, including microscopic and chemical data. Several contributions to Botany and Zoology are cited from the current or recent archeological literature. Archeologists are urged to continue to seek such data in future work.

CHEMICAL CHARACTERIZATION AS A MEANS OF EXPLORING THE PRODUCTION AND DISTRIBUTION OF CERAMIC ROOFING TILES IN WILLIAMSBURG, VIRGINIA. John D. Metz, Dept. of Archaeological Research, Colonial Williamsburg Foundation, Williamsburg, Va. 23187. Williamsburg and Jamestown are unique in that they appear to have been the sole loci of brick and tile production using an older, more medieval technology in North America. Analysis of the production and distribution of roofing tiles is difficult due to the absence of decoration and the highly standardized form. Specific production sites may be differentiated, however, through a unique chemical signature in ceramic paste resulting from differences in clay source and production techniques. Acid extraction analysis offers an affordable method of determining the compositional make-up of ceramics such as roofing tiles. This method produces highly precise results capable of intra-regional discrimination of production loci. Unlike other, more expensive techniques such as neutron activation analysis (NAA) and x-ray fluorescence (XRF), acid extraction does not require the total digestion of the artifact. Moreover, the technique provides reliable compositional data using conventional equipment.

AFRICAN AMERICAN FOODWAYS DURING THE 19TH CENTURY AT THE OCTAGON.
Elizabeth A. Moore and Rebecca Hess, 4600 43rd Place, NW,
Washington, DC 20016. During the early 19th century The Octagon
was the Washington, D.C. residence of John Tayloe, wealthy Virginia
plantation owner, his wife Ann Ogle Tayloe, and their 13 children.
In 1993, excavations of the servant's hall and housekeeper's room
in the basement of the Octagon revealed six historic features and
activity areas. An undisturbed deposit in the servant's hall
yielded a zooarchaeological sample of almost 500 faunal specimens,
most of which were found in a single cluster, interpreted as a food
processing activity area. In addition to the zooarchaeological
data, historic data gathered from extensive files of records,
documents, and research reports were examined for references to
both private and public foodways. Various models have been
developed by researchers for the historic utilization of fauna for
the East Coast in general, and, more specifically, the Chesapeake
area. In an examination of these models, a better understanding of
the lifeways of the servants, their access to faunal resources, and
their participation in the local economy will be developed.

SETTLEMENT AND CRM: PREHISTORIC LAND USE IN VIRGINIA'S POWELL VALLEY.

Stevan Pullins and Jane Peterson, Ctr. for Archaeological Res., Col. of
William and Mary, P.O. Box 8795, Williamsburg, VA 23187-8795. The College
of William and Mary Center for Archaeological Research conducted a series
of Phase II investigations on eight archaeological sites in Lee County,
Virginia, in the vicinity of the towns of Pennington Gap and Dryden. Sites
were temporally and functionally diverse, dating from the Early Archaic
through late Woodland periods and consisting of small temporary camps,
upland farmsteads, lithic procurement sites, and larger villages. The
results of these investigations were used in conjunction with previous
survey results, soil and physiographic data, and patterns of material
culture to lay the groundwork for a diachronic model of prehistoric
settlement in the Powell Valley.

TALES OF THE ORDINARY: EARLY TAVERNS OF ROCKBRIDGE COUNTY, VA. Kurt C. Russ and John-Paul Lunn, Lab. of Anthropol., Washington and Lee Univ., Lexington, VA 24450. An historical

and archaeological survey of taverns in Rockbridge County, Virginia was initiated by the staff of
Washington and Lee's Laboratory of Anthropology in the Fall of 1994. A research design was
formulated which outlined general project goals as well as specific research questions and hypotheses.
The goals ranged from identifying and locating county taverns to developing an historic context for
understanding the data base to testing selected tavern sites archaeologically. Research questions focus
generally on commerce in Rockbridge County and include a consideration of factors affecting the
distribution of taverns across space and through time, the evolution in tavern function, their organization,
self-sufficiency, and the nature of the labor force utilized, the lifeways of the taverners and their
compliance with governmental regulations, and the impact of taverns on the local economy.

The vast majority of the 17 taverns identified were situated along major corridors of travel especially the
"Great Road" and to a much lesser extent the Lexington-Covington turnpike. Specific clustering of sites
related to developing communities along this route including one cluster in the vicinity of Fairfield/
Brownsburg and another in Lexington as well as a third in the southern portion of the county adjacent to
Natural Bridge. Archaeological testing at two of the sites, Mackey's Tavern and Barclay's Tavern,
provide for explication of material culture patterning at two late-18th-through early-19th-century
Rockbridge taverns.

RELOCATING THE FOUNDATIONS OF JENNIE DEAN'S VISION: ARCHAEOLOGICAL INVESTIGATIONS AT THE MANASSAS INDUSTRIAL SCHOOL, 44PW505. John H. Sprinkle, Jr., Louis Berger & Associates, Inc., Washington, DC 20006. In October 1993, Louis Berger & Associates, Inc. (LBA) conducted field investigations at the Manassas Industrial School (44PW505) in Manassas, Virginia. Established during the late nineteenth century by an former slave, Jennie Dean, the Manassas School was the only vocational school for black youth located in Northern Virginia. Dedicated by Frederick Douglass in 1894 and partially funded by Andrew Carnegie during the early twentieth century, the school operated as a private, residential, and co-educational institution until the late 1930s when it was taken over by the Prince William County School system. LBA's study was designed to locate the foundations of three academic structures that had been demolished in the early 1960s. Methodology included the use of historic maps, limited machine trenching and supplementary shovel testing to identify the outlines of Hackley and Howland Halls, and the Carnegie Building. In addition, LBA prepared a National Register of Historic Places nomination for the property. This paper discusses the methodology and results of the archeological investigations at the Manassas Industrial School. (Sponsored by The Manassas Museum and the City of Manassas)

HITTING THE NAIL ON THE HEAD: NAILS AND THEIR MEANING ON A SLAVE SITE. Michael A. Strutt, Dept. of Archeology, Jefferson's Poplar Forest, Forest, Va. 24551. Nails are found in abundance at many slave cabin sites across Virginia. Archeologists have for the most part only categorized them into sizes and manufacturing technique when cataloguing these ubiquitous artifacts. The author will suggest that it may be possible to tease more information out of a collection by looking at the way nails are dispersed on a site and the state of the nails, ie used/unused, clinched, pulled etc. By doing this and looking at the relative percentages of nails to other artifacts it may be possible to understand more than the architecture of the missing cabins. Comparing data from an excavated slave cabin at Poplar Forest to other excavated sites an expanded interpretation of our sites may be possible.

HISTORICAL DEVELOPMENT AND USE OF WOODEN WATER PIPE AND THE RECOVERY OF A TWENTIETH-CENTURY EXAMPLE FROM HOPEWELL, VIRGINIA. Kenneth E. Stuck, William and Mary Center for Archaeological Research, P. O. Box 8795, Williamsburg, Va. 23187. Wooden water pipelines are no longer in use today, but not that long ago wooden water pipe was considered to be a valid choice, technologically and economically, for utility companies and municipalities. As late as the first quarter of this century, water companies serving urban areas like Norfolk, Virginia were installing complete or partial wooden pipelines, above and below ground, to carry water from reservoirs to pumping stations. Some areas also used wooden pipe as part of the regular water distribution network that connected the company to its customers. This paper will examine the development of wooden water pipe technology and the advantages and disadvantages of wood pipe, and then focus on an attempt to archaeologically recover a portion of one of these pipes in Hopewell, Virginia.

THE LONG MOUNTAIN COMMUNITY: BLACK AND WHITE RELATIONS IN THE LATE NINETEENTH/EARLY TWENTIETH CENTURY. George A. Tolley and Mark Martin, George Washington and Jefferson National Forests, 5162 Valleypointe Parkway, Roanoke, VA 24019. In this paper, the authors discuss the relationships between black and white residents within the Long Mountain Community of Amherst County, Virginia. The authors utilize Forest Service acquisition records, abstracts from land sales, Census Records, field observations, and the transcript from an interview with an African American native of Long Mountain to relate history and land settlement patterns for this area. Following the Civil War, land settlement patterns changes as economic conditions forced the sale of large estates and freed slaves needed to find housing and jobs. By the beginning of the Twentieth Century, African Americans owned the majority of the land within the community. Euro and African American land owners and share croppers lived as neighbors as they struggled to bring stability to their lives during the depressed economic conditions of the late Nineteenth Century.

FURTHER ANALYSIS OF THE POPE SITE: AN EIGHTEENTH CENTURY FARMSTEAD IN SOUTHAMPTON COUNTY, VIRGINIA. Esther C. White, Mount Vernon Ladies' Association, Mount Vernon, Va. 22121. Originally excavated by the College of William and Mary, the Pope Site is an eighteenth century farmstead. Located in Southampton County, Virginia, the site consisted of a main structure and three outbuildings interpreted as a kitchen, smokehouse, and slave quarter. This interpretation will be explored through an examination of the artifacts found at each structure. The ceramic vessels, especially the colonoware, a locally produced coarse earthenware often associated with slave quarters, will be an integral part of the analysis.

Astronomy, Mathematics and Physics

PHOTOMULTIPLIER TUBE CALIBRATION. Robert Atkins, Dr. Kevin Giovanetti, Department of Physics, James Madison University, Harrisonburg, Va. 22807. Photomultiplier tubes (pmt's) for the CEBAF Large Acceptance Spectrometer's (CLAS) Forward Electromagnetic Calorimeter (EMC) are currently being tested at JMU. Measurements of dark current and linearity are made to access the pmt's characteristics and make a first step towards understanding the response of the EMC detector. An overview of pmt's, the testing setup, and the current results of the tests will be presented.

DATA COMPRESSION USING WAVELETS AND WAVELET PACKETS, Brian Bradie, Dept. of Mathematics, Christopher Newport Univ., Newport News, VA 23606-2998. Fundamentally, data compression involves detecting and removing redundancies from a given data set. Techniques for data compression typically fall into one of two categories: (1) direct techniques, which process the data samples in the original representation in which they were recorded; and (2) transform techniques, which attempt to isolate the underlying features contained in the data by first expressing the data in terms of a different representational basis. Wavelets and wavelet packets are recently developed tools in applied mathematics which fall into the latter category of compression methods. In this survey, a brief introduction to the philosophy of wavelets and wavelet packets, to the efficient computation of each transform and to the concept of a best wavelet packet basis is provided. A variety of procedures for using wavelet and wavelet packet transform coefficients to obtain data compression are then described. The fast approximate factor analysis algorithm of Coifman and Wickerhauser (1992) is included in the presentation. The compression of single lead electrocardiogram data is used for illustrative purposes.

ENERGETICS AND SPECTROSCOPY OF FORMING GROUP 2 DIHALIDES.

Thomas C. DeVore, Dept. of Chemistry, James Madison University, Harrisonburg, VA 22807 and J. L. Gole*, School of Physics, Georgia Institute of Technology, Atlanta, Georgia 30332 The M (Ca, Sr, Ba) + X₂ (Cl₂, Br₂) reaction encounters produce unstructured visible chemiluminescence under single collision conditions. The second order dependence of the emission intensity suggests that this emission results from MX₂ molecules rather than the MX molecules more typically found during this type of reaction. A combination of multiple collision chemiluminescent studies and laser induced fluorescence spectroscopy has been used to demonstrate the highly efficient collisional stabilization of these electronically excited Group 2 dihalide collisional complexes. The first discrete emission spectra for each of these complexes have been obtained and analyzed. Discrepancies between the bond strengths determined by mass spectroscopy and from chemiluminescence measurements will also be discussed.

NEW CCD PHOTOMETRY OF FAINT CEPHEID VARIABLE STARS. David L. DuPuy and Robert W. Youngren*, Department of Physics and Astronomy, Virginia

Military Institute, Lexington, VA 24450. New observations of faint Cepheid variable stars have been obtained, using the VMI 0.5m telescope and electronic imaging. Cepheids are important links in the chain of distance measurements leading ultimately to the Hubble constant. We observed stars which had not been observed during the past 40 or more years, to look for changes in light curves or pulsation periods, and to obtain detailed light curves. In our sample of 15 stars, we found two with dramatically altered pulsation, and we obtained improved periods for several other stars. A brief discussion of the procedure and errors in CCD photometry will also be presented.

DESIGN AND IMPLEMENTATION OF A CONTROL SYSTEM FOR CEBAF DETECTORS. Darren Ellis, Dr. Kevin Giovanetti, Department of Physics, James Madison University, Harrisonburg, Va. 22807. The CEBAF large acceptance spectrometer's forward electromagnetic calorimeter will require routine calibration. Development of a calibration system to perform this operation is currently underway at JMU. Once development is complete, the calibration system will be integrated into the existing framework set forth by the data acquisition and slow controls being developed for the CLAS detector. An overview of the design and implementation aspects of this project will be presented.ATM ACCESS STRATEGIES FOR CEBAF CLAS DETECTOR SYSTEMS. David E. Game, Lisa P. Mitchell* and David C. Doughty, Dept. of Physics and Computer Science, Christopher Newport University, Newport News, Va. 23606. The data acquisition systems for particle physics have employed a number of strategies, primarily employing customized equipment. Here we present the results of a study which involves using simulation to analyze access strategies for a design which employs an ATM switch as the primary means of data transfer from read out controllers to the analysis farm and subsequently to the permanent storage medium. Given the non-deterministic nature of the ATM switch, the study focuses on strategies which attempt to assure delivery by avoiding congestion on a single output port.

CONFIRMATION AND CLARIFICATION OF THE ORBITAL ACCELERATIONS OF JUPITER'S GALILEAN SATELLITES. Kenneth C. Jacobs, Dept. of Physics, Hollins Col., Roanoke, Va. 24020, & Samuel J. Goldstein, Jr., Dept. of Astronomy, Univ. of Va., Charlottesville, Va. 22903. Early in 1995 we heard from Fred Franklin of Harvard College Observatory that their 20-year project with the Galilean moons had revealed an orbital acceleration for Io of order $2 \times 10^{-10} \text{ yr}^{-1}$. This independent support for our 1986 result of $4.6 \times 10^{-10} \text{ yr}^{-1}$ led us to re-examine both our 1986 work and our published errata of 1987. [There is also a new value for the total heat flow power from Io (between 1983 and 1993): $10.5 \times 10^{13} \text{ W}$.] We have now corrected all algebraic errors, and have confirmed our 1986 results anew: Io is accelerating at $\dot{n}_1/n_1 = 5 \times 10^{-10} \text{ yr}^{-1}$, Europa is accelerating at $\dot{n}_2/n_2 = 2 \times 10^{-10} \text{ yr}^{-1}$, and Ganymede seems to be decelerating at $\dot{n}_3/n_3 = -4 \times 10^{-10} \text{ yr}^{-1}$. This talk will clarify our many new findings. (Supported in part by a Faculty Travel Grant from Hollins College.)

NUCLEON RESONANCE ELECTROPRODUCTION AT LARGE MOMENTUM TRANSFERS Cynthia Keppel Virginia Union University, Richmond, VA. The description of hadrons (protons, neutrons, mesons) and their excitations in terms of elementary quark and gluon constituents is one of the fundamental challenges in physics today. Bloom-Gilman Duality is an observed phenomenon in electron scattering which suggests a common origin for both deep inelastic scattering (scattering from pointlike quarks in the nucleon) and nucleon resonance excitation. Nucleon resonance electroproduction data obtained at the Stanford Linear Accelerator Center (SLAC) and proposed for the Continuous Electron Beam Accelerator Facility (CEBAF) will be presented. These data, obtained from scattering high energy electrons (up to 6 GeV proposed at CEBAF and up to 20 GeV at SLAC) from hydrogen targets, will be discussed in light of Bloom-Gilman duality.

COUPLING BETWEEN ELECTRONS AND ACOUSTIC PHONONS IN QUANTUM DOTS AND OTHER NANOSTRUCTURES. Peter A. Knipp, Dept. of Physics and Comp. Sci., Christopher Newport Univ., Newport News, VA 23606, & Thomas L. Reinecke, Naval Research Lab, Washington, DC 20375. We show that the coupling between electrons and acoustic phonons in semiconductor confined structures occurs via a novel interaction, which we call the "ripple" mechanism, in addition to the usual deformation potential coupling. The ripple mechanism coupling arises from the perturbation of electron wavefunctions by the motion of interfaces. Detailed expressions for this coupling are derived here which are valid for all nanostructure systems, including those with quasi-zero, one and two dimensional geometries. Calculations of the electron scattering rates due to acoustic phonons have been made for semiconductor quantum dots in the shapes of spheres, cubes and rectangular parallelepipeds. It is found that scattering due to the ripple mechanism dominates that from the deformation potential for dot sizes less than several hundred angstroms and that it can be much larger for small dot sizes. (Supported in part by the U. S. Office of Naval Research and by the Office of International Studies at Christopher Newport University.)

TIME DECAY OF THE LOCAL ENERGY FOR A TWO-DIMENSIONAL DISPERSIVE WAVE. J.E. Lin, Dept. of Mathematical Sciences, George Mason University, Fairfax, Va. 22030. It has been known that solitons can emerge from initial pulses of arbitrary shape and amplitude whose central frequencies are at the zero-dispersion point of a single model fiber. In this paper, we consider a weak perturbation of it in another direction and show that the local energy of this two-dimensional wave decays in time.

The equation of this study is

$$u_t - u_x + u_{xxx} + i|u|^2 u = -w_y, \quad \text{where } i=\sqrt{-1}, \quad w_x = u_y.$$

OPERATION AND DESIGN OF THE CLAS FORWARD ELECTROMAGNETIC CALORIMETER. Dustin E. McNulty, Dr. Kevin Giovanetti, Department of Physics, James Madison University, Harrisonburg, Va. 22807. Electromagnetic calorimeters (EMC's) are an important tool in determining the properties of particles resulting in high energy collisions. Specifically, the CEBAF Large Acceptance Spectrometer's (CLAS) Forward EMC will be used to help distinguish electrons from pions and measure photon and neutron energies. The CLAS EMC is a total absorption shower calorimeter that employs lead sheets (to induce showering), and plastic scintillators together with photomultiplier tubes to fractionally sample the total energy deposited. An overview of this detector will be presented in conjunction with work being done on the calibration of this detector ongoing at JMU.

"CCD'S, IMAGE-PROCESSING, AND ORBITS--SUMMER SKIES AT JMU OBSERVATORY". Joseph W. Rudmin and Geoffrey Williams, Physics Dept., James Madison Univ., Harrisonburg, VA, 22807. During the summer of 1994, the authors implemented image acquisition at the Stokesville Observatory using a Celestron Compustar 14 telescope, and a Linx ST-4 Charge Coupled Device (CCD), with a Macintosh interface. Elements of the project included learning to use the Linx hardware and software, construction of a cabinet for transport and testing of the CCD, acquisition of images, and preliminary development of programs to convert data to IBM-PC formats, to process the images using Fourier decomposition, and to begin orbit computational techniques with a goal of determining the orbits of asteroids. A significant development was to implement a new technique of calculating orbits using a variation on the Picard Iteration, developed by James Sochacki and G. Edgar Parker of the JMU Mathematics Department. Results will be presented.

Biology

EFFECTS OF TEMPERATURE AND TERMITE HOST STARVATION ON FEEDING BY PROTOZOAN SYMBIONTS IN RETICULITERMES FLAVIPES (ISOPTERA; RHINOTERMITIDAE). Lisa A. Belitz & Deborah A. Waller, Dept. of Biol. Sci., Old Dominion Univ., Norfolk, Va. 23529. Termites rely on cellulolytic intestinal protozoan symbionts to digest their cellulosic foods. We examined food acquisition in termite hindgut protozoans by following phagocytosis of red paper fed to the termite host. Protozoans in termites maintained at 32°C and 26°C acquired red paper sooner than in those held at 22°C. Two protozoan species, Pyrsomymptha and Dinenympha, disappeared after 72 hours at 32°C, but other protozoan species were unaffected by temperature. Protozoans in termites starved for 24 hours incorporated red paper faster than those in termites with continuous access to food.

AGGREGATION OF DOPAMINE-BOUND HAEMOLYMPH PROTEINS BY THE AMERICAN COCKROACH. Daniel E. Buyas, W.D. Bailey*, R.R. Mills and T.D. Kimbrough, Dept. of Biol., Va. Commonwealth Univ., Richmond, Va. 23284-2012. Newly ecdysed American cockroaches, *Periplaneta americana*, greater than 600 mg were injected with ³H-dopamine or ¹⁴C-dopamine. Haemolymph was collected after 30 minutes. Size exclusion chromatography showed that 3 different molecular weight dopamine-bound proteins were present. Injection of each radiolabelled protein fraction into freshly ecdysed cockroaches resulted in their incorporation into the cuticular matrix. Rejection of the smallest haemolymph components resulted in *in vivo* protein aggregation with the radiolabel bound to higher molecular weight proteins.

EFFECTS OF HIGHER AND LOWER THAN NORMAL INCUBATION TEMPERATURES ON CHICK EMBRYO DEVELOPMENT. Karen L. Calfree & Carolyn M. Conway, Dept. of Biol., Va. Commonwealth Univ., Richmond, Va., 23284-2012. The teratogenic effects of hyperthermia and hypothermia on embryonic development were investigated using chick embryos (*Gallus domesticus*). Following incubation *in ovo* for 27 hours, embryos were removed from the yolk and cultured *in vitro* using the Spratt technique. While control embryos were cultured at 37.5 °C (normal incubation temperature), experimental embryos were cultured for 4 hours at either 40 °C or 35 °C and then returned to 37.5 °C for further incubation. All embryos were evaluated after 36 and 51 hours of total incubation using a morphological scoring system. Structures examined at 36 hours included the forming neural tube, notochord, somites, anterior intestinal portal, blood islands, Hensen's node, and primitive groove. Structures examined at 51 hours included the developing neural tube, eye primordia, heart primordium, somites, anterior intestinal portal, and blood islands. Mean embryo length, number of somite pairs and total morphological score of hyperthermic and hypothermic embryos were significantly decreased relative to that of control embryos. Developmental retardation was noted especially in the anterior neural tube (brain primordium), eye primordia, and heart primordium. These results were consistent with our hypothesis that hyperthermia and hypothermia would be teratogenic during the critical stages of development when organ primordia are being established. (Supported by the Undergraduate Research Grant Program at VCU)

MACROPHAGE AND GRANULOCYTE POPULATIONS AROUND NORMAL AND LIPOPOLYSACCHARIDE-INDUCED RESORBING EMBRYOS IN CD-1 MICE. F. M. Conors and A. F. Conway, Dept. of Biol., Randolph-Macon Col., and C. M. Conway, Dept. of Biol., Va. Commonwealth U. Lipopolysaccharide-induced pregnancy loss (resorption) in CD-1 mice was studied by injecting pregnant CD-1 mice intravenously with 0.05 ml of 0.1 mg/ml *E. coli* lipopolysaccharide (LPS, Sigma) on day 9 of gestation. Females were sacrificed by excess etherization at 6, 18, 24, or 30 hours after treatment. Mature macrophages were identified by peroxidase-labeled antibody staining for the F4/80 antigen. Granulocytes were identified by staining for endogenous peroxidase resistant to inactivation by methanol + peroxide (resistant peroxidase). Cells stained for F4/80 were primarily large cells with extended processes, with a minority of smaller rounded cells near blood vessels. Resistant peroxidase positive cells were small spherical cells containing either bi- or three to five-lobed nuclei. Both F4/80⁺ and resistant peroxidase⁺ cells were primarily localized in the mesometrial myometrium and were rare at the maternal-embryonic interface. Both cell populations were increased in LPS-treated females, with increases being statistically significant for resistant peroxidase⁺ cells. Because of their locations, neither of these cell populations are likely to participate directly in destruction of embryonic tissues during lipopolysaccharide-induced pregnancy loss.

THE EFFECTS OF TAMOXIFEN ON HEPATOMA CELLS. Robert M. Covington and Rosemary Barra, Department of Biological Sciences, Mary Washington College, Fredericksburg, VA 22401. Tamoxifen is a drug currently used for the treatment of women with estrogen positive breast cancer. Recent evidence indicates that a side effect of the tamoxifen treatment may be the induction of liver carcinomas. In this study, experiments were performed to determine the effects of tamoxifen on cultured Morris Hepatoma 7777 cells. These cells were incubated for four days with concentrations of tamoxifen from 0 to 100 nM. Trypan blue exclusion was used as an indicator of cell viability and the results showed that incubation with 100 nM Tamoxifen resulted in a 62.5% toxicity. The results of experiments that measured H³-thymidine incorporation into DNA indicate that tamoxifen inhibited incorporation up to 25%.

LOW OXYGEN EFFECTS ON NITROGEN FIXATION RATES IN TERMITES (ISOPTERA: RHINOTERMITIDAE). Anthony D. Curtis and Deborah A. Waller, Department of Biological Sciences, Old Dominion Univ., Norfolk, VA 23529. Termite hindguts harbor bacteria that are able to fix atmospheric nitrogen. We examined nitrogen fixation rates in *Reticulitermes* workers under low oxygen conditions which may occur in subterranean galleries. We also examined the effect of elevated CO₂ on nitrogen fixation. We generated 16.55% oxygen atmospheres by the addition of CO₂, argon, or N₂ gases; termite nitrogen fixation rates were higher in 16.55% O₂ atmospheres than in 18.55% O₂ atmospheres. There was no difference in nitrogen fixation rates between termites exposed to normal atmospheric concentrations of CO₂ and atmospheres containing 300 times atmospheric CO₂. However, when termites were exposed to 90% and 95% CO₂, nitrogen fixation rates decreased due to CO₂ narcosis. These results show that nitrogen fixation in termites is oxygen sensitive and is not affected by CO₂ levels below the point of narcosis.

ECTOPARASITES OF WHARF RATS IN NEW ORLEANS. Ralph P. Eckerlin, Harry F. Painter, Northern VA Comnty. Col., Annandale, VA 22003, Lance A. Durden, Institute of Arthropodology and Parasitology, Georgia Southern Univ. Statesboro, GA 30460, and Maurice D. Little, Dept. of Tropical Medicine, Tulane Univ. Medical Center, 1501 Canal St., New Orleans, LA 70112. Between November 1988 and March 1990, 93 Rattus norvegicus and 89 Rattus ratus were trapped near wharves along the Mississippi River in New Orleans, LA and examined for external and internal parasites. Because animals were pooled, no prevalence or intensity of infection data are available. However, total numbers of ectoparasites found are as follow: ACARI - Laelaps (Echinolaelaps) echidna 1 nymph, 125 females, 2 males; Laelaps (Laelaps) nuttalli 19 females; Ornithonyssus bacoti 2 nymphs, 8 females. ANOPLURA - Polyplax spinulosa 1 nymph, 1 female; Hoplopleura pacifica 1 nymph, 1 male. SIPHONAPTERA - Xenopsylla cheopis 17 males, 27 females; Ctenocephalides felis 5 females; Nosopsyllus fasciatus 1 female. The "plague flea", X. cheopis, was the most abundant flea collected. In light of the recent epidemic of human plague that occurred in India, and the speed of modern travel, we suggest that rat control measures and periodic monitoring of rat ectoparasite populations in port cities such as New Orleans, be continued.

NOT ALL AQUATIC ASTIGMATID MITES WALK! SWIMMING BEHAVIOR IN THE GENUS CREUTZERIA (ACARINA : HISTIOSTOMATIDAE). Norman J. Fashing, Dept. of Biol., Col. of William and Mary, Williamsburg, Va. 23187. Heretofore swimming in the Acarina (mites) has been considered a trait of so called "water-mites" (Hydracharina), suborder Prostigmata; whereas the literature on other suborders including the Astigmata, a diverse assemblage with over 785 genera in 69 families, contains no mention of natatory behavior. While fully aquatic species are not common in the Astigmata as a whole, they are not unusual for the families Acaridae, Algophagidae, Hyadesiidae, and Histiostomatidae. The literature would indicate, nonetheless, that these mites are ambulatory, clinging to the substrate when walking. Members of the histiostomatid genus Creutzeria, inhabitants of the fluid-filled pitchers of plants of the family Nepenthaceae, are an exception - adults and instars other than the deutonymph are so modified that they are unable to walk and must swim. Morphological adaptations for swimming include a spherical body with a thin, smooth integument, as well as the shape, orientation and location of the legs and leg setae.

PROBLEMS IN USING BIOTINYLATED ANTIBODIES FOR ELISA MEASUREMENT OF TUMOR NECROSIS ALPHA CONCENTRATIONS AROUND NORMAL AND LIPOPOLYSACCHARIDE-INDUCED RESORBING EMBRYOS IN CD-1 MICE. W. A. Fritz, C. P. Toomey, and A. F. Conway, Dept. of Biol., Randolph-Macon Col., and C. M. Conway, Dept. of Biol., Va. Commonwealth U. When higher than expected values were observed in ELISA measurements of homogenates of samples punched from thick frozen sections of mouse implantation sites, a series of control experiments revealed that high values were obtained from many samples when the biotinylated primary antibody was omitted from the sequence. Our experience indicates that a control in which the biotinylated antibody is omitted but which is treated with the streptavidin-peroxidase or avidin-peroxidase reagent in the normal fashion should be run for each sample when analyzing homogenates in ELISA techniques using biotinylated antibody technology.

POSSIBLE EVIDENCE OF NON-RANDOM MATING IN COTTON STAINER INSECTS FROM ST. THOMAS, USVI. Harold J. Grau, Dept. of BCES, Christopher Newport Univ., Newport News, Va. 23606. The Insect genus *Dysdercus* (Pyrrhocoridae; Heteroptera) is known collectively as the cotton stainers because many of its species have feeding habits that include the transfer of a fiber-staining fungus to the cotton bolls they feed on. Other food sources include various Malvaceous plants. One New World species, *D. andreae*, inhabits most of the islands of the West Indies. On St. Thomas, US Virgin Islands, the species is found exclusively in association with *Thespesia populnea* trees, feeding on its seeds. Among the behaviors exhibited by these bugs is prolonged copulation, in which mated pairs remain *in copula* for extended periods of time. It is not clear if mating in these insects is random. In random mating, one would expect to find that, if variation in body size exists among adults, there should be no correlation among body sizes of mated adult males and females within a pair. Also, in a random mating system, there should be no difference in body sizes between unmated and mated adults. To examine whether the mating system of these insects is random, body sizes of mated and unmated adult *D. andreae* were measured from several populations on St. Thomas, USVI. Three indicators of body size were used: pronotum width, wing length, and thorax-abdomen length. There was no significant difference found in the body sizes of mated and unmated adults. However, statistically significant correlations were found among the measured body size indices of mated males and females, that is, larger males tended to be mated with larger females. These results suggest that mating in this insect is not random, but based in part on size selection within a pair.

INTERACTIONS BETWEEN LIPOPOLYSACCHARIDE-COATED LATEX MICROSPHERES AND IMPLANTATION SITES IN CD-1 MICE. H. A. Harden and A. F. Conway, Dept. of Biol., Randolph-Macon Col., and C. M. Conway, Dept. of Biol., Va. Commonwealth U. In an attempt to produce a probe visible by fluorescent microscopy and which could be used to follow the distribution of injected lipopolysaccharide during lipopolysaccharide-induced pregnancy loss (resorption) in CD-1 mice, pregnant CD-1 mice were injected with 1 micrometer diameter fluorescent latex microspheres (Polysciences) coated with *E. coli* lipopolysaccharide (LPS, Sigma) or with control preparations on day 9 of gestation. All females were sacrificed by excess etherization on day 12 of gestation. Overnight incubation of microspheres in 2 mg/ml LPS in phosphate buffered saline produced preparations which contained in excess of 3 micrograms of LPS (as measured by competition ELISA) per 0.05 ml injection and which caused marginally significant body weight losses when injected intravenously or subcutaneously in the tail, but which caused no increase in the frequency of resorption. Microspheres incubated with 5 mg/ml concanavalin A followed by incubation with 2 mg/ml LPS caused statistically significant body weight loss and statistically marginal increases in the frequency of resorption. These results suggest that the polysaccharide part of LPS is important in body weight loss but that the lipid A part is important in inducing pregnancy loss.

DISTRIBUTION OF APOPTOTIC CELLS AND FRAGMENTED DNA AROUND NORMAL AND LIPOPOLYSACCHARIDE-INDUCED RESORBING EMBRYOS IN CD-1 MICE. S. L. Harris and A. F. Conway, Dept. of Biol., Randolph-Macon Col., and C. M. Conway, Dept. of Biol., Va. Commonwealth U. Involvement of apoptosis in lipopolysaccharide-induced induced pregnancy loss (resorption) in CD-1 mice was studied by intravenously injecting pregnant CD-1 mice with 0.05 ml of 0.1 mg/ml *E. coli* lipopolysaccharide (LPS, Sigma, control = 0.05 ml phosphate-buffered saline) on day 9 of gestation. Females were sacrificed by excess etherization at 6, 24, or 48 hours after treatment and apoptotic nuclei were detected in transverse frozen sections of implantation sites by staining for fragmented DNA (Oncor kit). Control samples contained scattered apoptotic nuclei in decidual tissues and exhibited a diffusely stained region at the maternal-embryonic interface. Treatment with LPS resulted in loss of most apoptotic nuclei from decidual tissues and extensive expansion of the diffusely stained interface zone by 24 hours after treatment. These results are incompatible with typical apoptosis as a major mechanism of cell loss at the normal maternal-embryonic interface or during pregnancy loss induced by LPS treatment.

COEVOLUTIONARY IMPLICATIONS OF BREEDING CESSATION IN CUTEREbra-INFESTED PEROMYSCUS POPULATIONS. Michael S. Hensley, Department of Biology, Bridgewater College, Bridgewater, VA 22812. The phenomenon of botfly (*C. fonsinella*) parasitism of white-footed mice (*P. leucopus*) has been studied for 23 years on three insular woodlots in the Shenandoah Valley. Botfly prevalence, host demography, and bot-induced biology are presented for 6,240 mice on the woodlots. Data suggest increased longevity and reduced fertility as a result of moderated infections. Such mice show greater winter survival and, subsequently, increased fertility during the spring breeding upsurge. Evidence for coevolved population ecology is strong on insular woodlots, but scant or lacking in expansive forests. Differences are attributed to the more intimate contact of two small, static gene pools in the insular woodlot environment.

INFESTATION RATES AND BIOMASSES OF A STOMACH ASCARID IN A POPULATION OF SIGMODON HISPIDUS, THE HISPID COTTON RAT, OF SOUTHEASTERN VIRGINIA. Barbara Hiller and Robert K. Rose, Dept. of Biol. Sci., Old Dominion Univ., Norfolk, Va. 23529. A population of hispid cotton rats, *Sigmodon hispidus*, from southeastern Virginia infested with stomach worms was studied for its patterns of reproduction from 1987 to 1990. The hispid cotton rat is a cricetine rodent found in grass-dominated habitats and has an omnivorous diet consisting mainly of grasses and insects. Animals were collected using Fitch and Sherman live traps baited with birdseed from an old field in Portsmouth, Virginia. Animals over 50 grams were brought back into the laboratory and sacrificed using chloroform. Necropsies were performed in which stomachs were extracted and examined for internal parasites. The rats become infested by swallowing insects carrying encapsulated eggs. Approximately 23% of all animals collected were found to have loads of an ascarid worm, which were removed and stored in 70% alcohol. Parasite sex and biomasses were recorded. One-third of those animals infested were found to have parasite loads containing only one sex. The original study site was revisited in the Spring of 1995 and additional sampling showed that the population continued to be infested.

CYTOTOXICITY OF LAK CELLS AGAINST ME-180 CELLS. Rodney L. Madagan and Rosemary Barra, Department of Biological Sciences, Mary Washington College, Fredericksburg, VA 22401. Lymphokine activated killer (LAK) cells are clearly an important component in the immune systems arsenal against cancer cells. The proliferation of these cells is known to be dependent upon the action of cytokines, and studies are being performed to evaluate the role of various factors in the differentiation and proliferation of this specific cell type. The aim of this project is the evaluation of the effects of two major cytokines, IL-2 and interferon gamma, to determine if they act synergistically on LAK cell cytotoxicity against cancer cells. Freshly isolated lymphocytes were initially stimulated for 24 hours with 500 units of IL-2. The cells were then harvested and plated in 12 well culture plates and incubated with 1000 units of IL-2 and 1000 units of INF- for an additional 24 hours. At the end of this incubation period, the cells were transferred to well plates containing ME-180 cervical carcinoma cells and their cytotoxic effects were determined. The results of these experiments indicate that this treatment protocol resulted in 42% cytotoxicity which represents a 15% increase over treatment with IL-2 alone. The presence of LAK cells was confirmed by the binding of anti-CD16.

THE POPULATION DYNAMICS OF *Oryzomys palustris*, THE MARSH RICE RAT, FROM EASTERN SHORE TIDAL MARSSES. John A. March Jr.* and Dr. Robert K. Rose. Dept. of Biol., Old Dominion Univ., Norfolk Va. 23508. A year-long mark-and-recapture study was conducted on two grids located in costal tidal marshes on the Eastern Shore of Virginia. Population densities of *Oryzomys palustris* were greatest in late summer and early winter. *Microtus pennsylvanicus* cohabited the study areas with *O. palustris*, and was present in greater numbers from May to July. Previously, few studies on the relationship of microtine rodents with other small mammals have been conducted.

THE IMPORTANCE OF PLANT SECONDARY COMPOUNDS TO HIGHER TROPHIC LEVELS: EFFECTS OF SINIGRIN ON THE CABBAGE BUTTERFLY, *PIERIS RAPAE* AND ITS HYMENOPTERAN PARASITOID, *COTESIA GLOMERATA*. Julie A. McNichol & D.N. Karowe, Dept. of Biol., Va. Commonwealth Univ., Richmond, Va. 23284. The effects of the plant secondary compound sinigrin, on the small white cabbage butterfly, *Pieris rapae*, and its hymenopteran parasitoid, *Cotesia glomerata*, were investigated. When fed diets containing sinigrin, *P. rapae* displayed increased relative consumption rate and relative growth rate, and decreased fifth instar duration. In contrast, average adult male wasp weight and host-parasitoid complex weight were both significantly lower when the caterpillars were fed a diet high in sinigrin. Neither wasp larval nor pupal mortality was affected by sinigrin. Hypotheses for the method of wasp exposure to and a general mode of action for sinigrin are presented. (Supported by a grant from the Undergraduate Research Program of Va. Commonwealth Univ.)

EFFECTS OF SALT-TREATED WOOD ON FEEDING AND SURVIVORSHIP IN TERMITES (RHINOTERMITIDAE; *RETICULITERMES*) FROM COASTAL AND INLAND FORESTS. Susan E. Morlino & Deborah A. Waller, Dept. of Biol. Sci., Old Dominion Univ., Norfolk, Va. 23529. Logs containing termites in a tidal wetland forest on the Eastern Shore of Virginia are frequently submerged under brackish water during high tides. We used choice and no-choice feeding tests to examine termite response to filter paper and wood blocks treated with solutions of differing salt concentrations. We compared termite feeding and survivorship responses to different salt treatments for termites from coastal tidal forests and from inland forests. Salt concentration had a significant effect on termite response, but there were no differences in response among termites from coastal versus inland habitats.

RESCUING ENDANGERED SPECIES: *PARTULA* ON MOOREA. James Murray, Dept. of Biol., Univ. of Va., Charlottesville, VA 22903, & Bryan Clarke*, Dept. of Genetics, Univ. of Nottingham, NG7 2UH, England. The land snails of the genus *Partula* have been studied as a model of evolutionary processes for more than 100 years. Unfortunately, an ill-considered introduction of the predatory snail *Euglandina rosea*, intended as a biological control for the Giant African Snail *Achatina fulica*, has resulted in the complete extirpation of the native snails. With the help of a number of zoos we have maintained breeding colonies of several of the Moorean species in captivity, and we hope eventually to be able to restore them to the wild. As a pilot project we have built an enclosure on Moorea housing three of the species, protected behind physical, chemical, and electrical barriers. The species in the enclosure have survived for six months and have begun to produce offspring. The enclosure experiment is designed to provide us with information about the interaction of the species with one another. (Supported by a grant from the University of California, Berkeley, through their Richard B. Gump South Pacific Biological Research Station.)

THE EFFECTS OF CHEMOTHERAPEUTIC AGENTS ON ME-180 CELLS AND p53 PRODUCTION. Katharine W. Nowell, Gary L. Brown and Rosemary Barra, Department of Biological Sciences, Mary Washington College, Fredericksburg, VA 22401. The p53 gene is an important regulatory gene for cell division. Recent studies indicate that the p53 protein functions as a transcription factor, binding upstream response elements to inhibit cell cycle progression. The mutated form of p53 is associated with the majority of human cancers and thus normal p53 is considered a suppressor protein.

The goal of this study was to determine the level of expression of p53 in Me-180 cells and to determine if doxorubicin treatment increases p53 expression. The p53 protein was isolated from ME-180 cells using immunoprecipitation and immunoblot procedures. The results indicate that low level p53 production is present in ME-180 cells and that the level is increased by the DNA damage associated with doxorubicin treatment.

BROWN-HEADED COWBIRD (MOLOTHRUS ATER) RANGE EXPANSION INTO THE SOUTHEAST: EFFECTS ON POULATIONS OF SELECTED PASSERINES. Elizabeth A. Pruitt and Robert K. Rose, Dept. of Biol., Old Dominion Univ., Norfolk, VA 23529. The Brown-headed Cowbird is an obligate brood parasite and host generalist. Because it is able to exploit a number of hosts, it is not limited by the density of a single species and can rapidly increase its numbers when expanding into new regions, threatening individual species. The objectives of this study are to determine the current breeding range of the Brown-headed Cowbird in the southeast, to document how densities within this range have changed over the study period and to determine how this invasion has affected several species of warblers and vireos which are potential hosts. The data used in this analysis was collected by the North American Breeding Bird Survey from 1966 through 1992 in Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama and Tennessee.

PATTERNS OF REPRODUCTION IN THREE SPECIES OF RODENTS IN NATURAL AND IRRIGATED FIELDS IN NORTHERN NIGERIA. Safianu Rabiu and Robert K. Rose, Dept. of Biol., Old Dominion Univ., Norfolk, VA 23529-0266. We studied the breeding patterns of Arvicanthis niloticus, Mastomys natalensis and Tatera valida in natural and irrigated fields near Kano, Nigeria, from July 1990 to June 1992. In the natural fields all species showed strict seasonal breeding in the rainy months (May-October), with Arvicanthis starting at the same time as the onset of the rains but a month or two ahead of Mastomys and Tatera. The peak of breeding activity for all species was in July - September. Mean number of 8.61 embryos was highest in Mastomys, followed by 5.30 and 3.41 embryos in Arvicanthis and Tatera, respectively. In contrast to reproduction in the natural fields, the breeding seasons in Arvicanthis and Mastomys in the irrigated fields were continuous. However, significantly larger reproductive organs and marginally larger mean litter sizes were observed during the rains compared to the dry months. These changes in gonadal sizes were influenced by seasonal changes that were unrelated to larger animals having larger gonads. Surprisingly, Tatera was completely absent from the irrigated fields. Thus, the responses to the application of irrigation water differed among the species.

EXTRACELLULAR CALCIUM REGULATES DIFFERENTIATION IN CULTURED EMBRYONIC CHICK DUODENA. J. Orion Rogers, Dept. of Biol., Radford Univ., Radford, VA. 24142.

This work ascertains the influence of extracellular calcium (Ca^{2+}) concentration in the absence and presence of the hormones thyroxine (T₄) and hydrocortisone (HC) on the development of the microvillar enzymes alkaline phosphatase (ALP) and the disaccharidases maltase (M) and sucrase (S). Duodena from 14-day-old chick embryos were cultured at 38° C for 48 h in Medium 199 containing either 0.7, 0.9, 1.3 or 2.8 mM Ca^{2+} in the absence or presence of hormones. In the absence of exogenous hormones, tissue ALP activity increases by 92% ($P < 0.005$) as extracellular Ca^{2+} is increased from 0.7 to 2.8 mM, but the activities of disaccharidases are not influenced by altering Ca^{2+} . In 1 nM T₄-treated cultures tissue ALP activity increases by 138% ($P < 0.0005$) as Ca^{2+} is increased from 0.7 to 2.8 mM, but M activity of T₄-treated tissue is not influenced by increasing Ca^{2+} . In 1 μM HC-treated cultures, tissue ALP activity increases by 80% as Ca^{2+} is increased from 0.7 to 0.9 mM, but further increases in Ca^{2+} do not influence ALP activity. HC stimulation of disaccharidase activity is unaffected by altering the extracellular Ca^{2+} . These data infer a role for Ca^{2+} in T₄ and HC mechanism of action.

THE SMALL MAMMAL COMMUNITY IN FORESTED WETLANDS OF SOUTHEASTERN VIRGINIA AS REVEALED BY PITFALL TRAPPING STUDIES. Robert K. Rose and Daryl H. Thomas, Dept of Biological Sciences, Old Dominion University, Norfolk, VA 23529. Small mammals were studied using pitfall traps in forested wetland habitats in Chesapeake, Virginia. In all, 39 0.25 ha study grids were placed at 21 sites along Route 17; each square grid had 25 pitfall traps (#10 tin cans sunk into the ground) placed at 12.5 m intervals. The southeastern shrew was the most common mammal taken during 29,250 nights of pitfall trapping, occurring on 19 of 21 study sites and comprising 61% of the 267 small mammals caught. Eleven other species were taken, with short-tailed shrews (Blarina brevicauda, N=65) and white-footed mice (Peromyscus leucopus, N=11) the only ones in double digits.**NATURAL KILLER CELLS ARE NOT ESSENTIAL FOR LIPOPOLYSACCHARIDE-INDUCED EMBRYO LOSS IN CD-1 MICE.** S. M. Schlager, F. M. Conors and A. F. Conway, Dept. of Biol., Randolph-Macon Col., and C. M. Conway, Dept. of Biol., Va. Commonwealth U. Involvement of natural killer cells in lipopolysaccharide-induced pregnancy loss (resorption) in CD-1 mice was studied by injecting pregnant CD-1 mice with either 0.2 ml of rabbit anti-asialo GM1 (Wako, control = 0.2 ml normal rabbit serum) intraperitoneally on day 7 (vaginal plug = day 1) of gestation or 0.05 ml of rabbit anti-asialo GM1 (Wako, control = 0.05 ml normal rabbit gamma globulin) intravenously on day 8 of gestation, both followed by intravenous injection of 0.05 ml of 0.1 mg/ml E. coli lipopolysaccharide (LPS, Sigma, control = 0.05 ml phosphate-buffered saline) on day 9 of gestation. All females were sacrificed by excess etherization on day 12 of gestation. Females treated with anti-asialo GM1 on day 7 or 8 followed by LPS on day 9 exhibited frequencies of pregnancy loss equal to or higher than the frequencies of pregnancy loss observed in females who received control treatments on day 7 or 8 followed by LPS on day 9 of gestation. Since the anti-asialo GM1 treatments were in excess of those needed to totally eliminate detectable natural killer cell populations, these results indicate that natural killer cells are not essential to the process of pregnancy loss by resorption induced by bacterial lipopolysaccharide.

HABITUATION OF AGGRESSIVE BEHAVIOR IN BETTA SPLENDENS. Jennifer Schuchert, Elsa Q. Falls, and Arthur F. Conway, Department of Biology, Randolph-Macon College, Ashland, VA 23005. Previous investigations have shown that aggressive behavior in fish is a reaction to the presentation of many kinds of external stimuli, including other fish, and that the behavior can be habituated under certain conditions. In this study the process of aggressive behavior habituation in Betta splendens males was investigated. The experiment compared the waning of aggressive behavior when males were exposed to one or two different stimulus fish of the same species every day over a period of twenty-one days. On day twenty-two, each experimental bettas was presented with a new fish. Results indicated that the habituation of aggressive behavior did occur over the twenty-one day period in both groups but at significantly different rates. The presentation of a new stimulus on day twenty-two did not produce significantly different aggressive behavior compared to day twenty-one.

AN INVESTIGATION IN SMALL MAMMAL HORMONE LEVELS:

RELEASE RATES OF TESTOSTERONE IMPLANTS. Erica A. Serabian, Department of Biology, Virginia Polytechnic Institute, 24061. Research supporting the use of testosterone implants as tools to increase aggressive behavior, along with the hypothesis that crowding effects the endocrine system, affecting reproductive condition leading to subsequent decline in population density, allows combination of these two ideas for application to field research. This investigation aimed to determine the average level of testosterone of mice treated with 1.0 and 1.5 mg testosterone implants. Six mice were injected with empty 10 mm Silastic tubing capsules (shams), seven mice were injected with 1.0 mg implants, and six mice were injected with 1.5 mg implants. Blood samples were taken on days 4, 7, and 14 by the orbital sinus bleeding method. Plasma was extracted, then analyzed by radioimmunoassay. There were significant differences found among treatments; the mean levels of testosterone differed among treatment groups ($P=0.001$). The effect of day was not significant ($P=0.28$), suggesting that effects of the implants were maintained throughout the investigation period. Group 1 (shams) consistently had higher and more variable testosterone levels than groups 2 and 3 (implants of methyl testosterone). Although the investigation did not accurately determine the release rates of the implants, it did show that controls and shams were not different. Implants filled with methyl testosterone suppressed natural testosterone and variation among individual testosterone levels. This supports the hypothesis that hormone implants are useful tools for research, as they can reduce individual variation and control testosterone levels.

IMPACT OF COPPER ON BENTHIC MACROINVERTEBRATES IN AN APPALACHIAN HEADWATER STREAM: A PRELIMINARY ASSESSMENT OF A RESTORATION SITE. Alicia Slater, M. Sanchez, A. C. Hendricks,

Dept. of Biol., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. Contamination by acid mine drainage has resulted in copper levels in East Prong Creek ranging from 16 to 23 ppb. The purpose of this study was to examine the effects of copper on benthic macroinvertebrate community structure and function prior to construction of a treatment wetland. Decreases in taxa richness ($\bar{n}=42$ at the reference site, $\bar{n}=26$ at the impacted sites) and abundance ($\bar{N}=768$ at the reference site, $\bar{n}=140$ at the impacted sites) were accompanied by a shift in community composition. Mayflies (Ephemeroptera) were the dominant taxa at the reference site, while true flies (Diptera) were dominant at the impacted sites. Decomposition rates of red maple (*Acer rubrum*) leaves were measured to determine the effects of copper on macroinvertebrate community function. Red maple leaves decomposed faster at the reference site ($k=0.048$) than at the impacted sites ($k=0.020$).

DISTRIBUTION OF MARSH RICE RATS (*ORYZOMYS PALUSTRIS*) AND MEADOW VOLES (*MICROTUS PENNSYLVANICUS*) IN A TIDAL MARSH ON THE EASTERN SHORE OF VIRGINIA. Allison L. Sowell * and Robert K. Rose, Dept. of Biol., Old Dominion Univ., Norfolk, VA. 23529. Relationships can frequently be seen between habitat structure and habitat use by small mammal species. Distribution patterns are influenced by seasonal changes in habitat structure. Although rice rats and meadow voles are both found in Eastern Shore marshes and show extensive overlap of their ranges, each species has specific habitat and niche preferences that prevent competition to the exclusion of the other species. Seasonal comparisons between species and their associated habitats show which elements of habitat structure are most important to each species. Live trapping with mark and recapture allowed for month by month examination of the movements of individual animals for as long as they remained active on the trap grids. (Supported by a grant from the Nature Conservancy)

CHEMICAL BASIS FOR THE ATTRACTION OF THE BLACK SWALLOWTAIL BUTTERFLY TO FENNEL. Leena M. Sumitra & Richard R. Mills, Dept. of Biol., Va. Commonwealth Univ., Richmond, Va. 23284-2012. Methanol-water extraction of fennel and subsequent removal of hydrophobic components with chloroform yielded a preparation containing polar compounds. Column chromatography on silica gel resulted in the separation of five different compounds that absorbed at 280 nm. Scans from 200 nm to 800 nm revealed spectra that matched two furanocoumarins, bergapten and xanthotoxin. We have concluded that furanocoumarins are present in fennel and they may be responsible for the chemical basis of host plant selection by the Black Swallowtail butterfly. (Supported by the Va. Commonwealth Univ. Undergraduate Research Grant Program)

NEST BOX USE BY WILD POPULATIONS OF WHITE-FOOTED MICE (*PEROMYSCUS LEUCOPUS NOVEBORACENSIS*) IN EASTERN VIRGINIA. C. Richard Terman, Laboratory of Endocrinology and Population Ecology, Department of Biology, College of William and Mary, Williamsburg, VA 23185. A population of white-footed mice on an 11-ha area was studied monthly during 1983-1989 with 600 live-traps and 254 wooden nest boxes attached to trees at 20 m intervals. Location, sex, age, body weight, and reproductive condition of individual animals were recorded. Data from nest boxes were consistent with those obtained via trapping, but rarely did more than 40% of the population occur in the nest boxes. Nest box use declined to less than 10% of the population during the summer (May-September). Nest box occupancy was inversely related to environmental temperature, i.e., less than 20% of the population occurred in nest boxes when the monthly minimum temperature rose above 8 C.. Other nest box techniques, perhaps subterranean nest boxes, appear to be required to study white-footed mice during the critical mid-summer breeding hiatus.

CONSEQUENCES OF TAIL AUTOTOMY ON *ANOLIS CAROLINENSIS*. Lowell W. Whitney and Werner Wieland, Department of Biological Sciences, Mary Washington College, Fredericksburg, VA 22401. Effects of caudal autotomy on the running speed and activity level in *Anolis carolinensis* were investigated. Tailed and autotomized lizards were chased down a track to measure running speed. The number of movements tailed and autotomized lizards made in an activity chamber were used as a measure of activity level. Tailed individuals were 50% faster ($p = 0.0006$) and showed a 24% higher activity level ($p = 0.04$) than did individuals that suffered a loss of their tail. This pattern is not, however, found in all lizards reported to exhibit caudal autotomy. Two patterns concerning the effects of caudal autotomy on running speed in lizards were observed. A decrease or increase in running speed after autotomy may be consistent within a family or infraorder. Also, the effect of autotomy on running speed and perhaps activity level may be correlated with tail size in lizards. Results from this study are consistent with both of these observations. Many species which undergo caudal autotomy have not been examined with regard to its effects on running speed or activity level. Additional studies should also examine the relationship between tail size and running speed in autotomized lizards.

THYROID HORMONES IN THE YOLK OF JAPANESE QUAIL EGGS. C. Morgan Wilson. Dept. of Biol., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061. Maternal thyroid hormones (THs) in egg yolk may be important in early avian development prior to the function of the embryonic thyroid gland. To evaluate this idea, I first developed methods for altering thyroid status of laying hens and for the extraction and measurement of THs in avian egg yolk. To develop a protocol for making hens hyperthyroid, laying hens were given a single oral dose of thyroxine (T₄) of 3X-6X thyroid secretion rate (TSR; 2.8ng T₄/100g body wt.). All doses significantly increased plasma T₄; from < 14ng T₄/ml to sustained concentrations of \geq 80 ng T₄/ml for hrs 3-6 after dosing; by 12 hrs, plasma T₄ levels had dropped considerably. These data indicate twice daily dosing of hens is necessary for sustained elevation of plasma THs. To determine the number of days of T₄ administration likely to produce eggs with elevated T₄, I administered two lipid soluble dyes orally on alternate days for 8 days. Results showed 5 alternating colored rings (i.e. days) of yolk deposition per egg. To verify a methanol/chloroform extraction procedure for extraction of yolk T₄ and the use of extracts in a TH radioimmunoassay, I demonstrated consistent recoveries of THs and accurate measurement of THs in extracts spiked with hormone. Based on the above methods, laying hens were dosed twice daily at 3X TSR to address the ability of hyperthyroid hens to transfer increased concentrations of T₄ to their eggs. Currently, I am analyzing TH yolk extracts from the eggs of hens that received 3X T₄ twice daily. (Supported by grants from Sigma Xi and the Graduate Research Development Project (Graduate Student Assembly of Va. Tech.))

THE DIET OF *Oryzomys palustris* BASED ON STOMACH CONTENT ANALYSIS. Shannon L. Wright*, Dept. of Biol., Old Dominion Univ., Norfolk, VA 23529 & Robert K. Rose, Dept. of Biol., Old Dominion Univ., Norfolk, VA 23529. The purpose of this study is to analyze the diet of *Oryzomys palustris*, the marsh rice rat, which is unusual in that it is one of two carnivorous mammals in the Family Muridae in North America. This is being accomplished by taking the animals from two study areas located in tidal marshes on the Eastern Shore of Virginia for a period of one year. Once caught, the animals are being sacrificed and their stomach contents examined. The contents are being identified to the lowest taxonomic level possible. This study will provide important information about the role of the rice rat as a consumer in its communities, and especially in tidal marshes on the Eastern Shore of Virginia.

Biomedical and General Engineering See page 161**Botany**

PATTERNS OF FOREST COMMUNITY COMPOSITION ON THE FERNOW EXPERIMENTAL FOREST AND ADJACENT PORTIONS OF OTTER CREEK WILDERNESS AREA. H. S. Adams, D. S. Lancaster Cmnty. Col., Clifton Forge, VA 24422, S. L. Stephenson, Dept. of Biology, Fairmont State College, Fairmont, WV 26554, R. Muzika*, USDA For. Serv., 180 Canfield St., Morgantown, WV 26505, D. M. Lawrence, Tree-Ring Lab., Lamont-Doherty Earth Obs. of Columbia Univ., Palisades, NY 10964, and G. W. Miller*, USDA For. Serv., Timber and Watershed Lab., Parsons, WV 26287. During the 1994 field season, quantitative data on composition and structure of the tree stratum (stems ≥ 10 cm DBH) were obtained from 105 twenty by fifty meter (0.1 ha) quadrats in the Fernow Experimental Forest and adjacent portions of the Otter Creek Wilderness Area in Tucker County, West Virginia. The study area is within the Allegheny Mountain section of the unglaciated Allegheny Plateau. Fifteen different species occurred as leading dominant in at least one quadrat. The most common examples were northern red oak (25 quadrats), yellow-poplar (22), sugar maple (15), and red maple (11). Positions of tree species along the first axis of a Detrended Correspondence Analysis (DCA) ordination derived using species importance values (one-half the sum of relative density and relative basal area) seemed to be most closely related to a moisture complex-gradient, whereas positions along the second axis appeared to correspond to an elevation complex-gradient. TWINSPAN analysis of the 105 quadrats delineated eight forest types, which were named on the basis of their leading dominants. Forest types represented by the greatest number of quadrats were northern red oak/sugar maple (39), yellow-poplar/sugar maple (27), northern red oak/red maple (15), and chestnut oak/red maple (14). (Supported in part by funds provided by the USDA Forest Service.)

SHORT-TERM DYNAMICS OF RED SPRUCE/HARDWOOD ECOTONES IN THE CENTRAL APPALACHIANS OF VIRGINIA AND WEST VIRGINIA. H. S. Adams, D. S. Lancaster Cmnty. Col., Clifton Forge, VA 24422, S. L. Stephenson, Dept. of Biology, Fairmont State College, Fairmont, WV 26554, M. B. Adams*, USDA For. Serv., Timber and Watershed Lab., Parsons, WV 26287, D. M. Lawrence, Tree-Ring Lab., Lamont-Doherty Earth Obs. of Columbia Univ., Palisades, NY 10964, and J. D. Eisenback, Dept. of Plt. Path., Phys., and Weed Sci., Va. Poly. Inst. and St. Univ., Blacksburg, VA 24061. We are investigating patterns of species composition and distribution, ecologically important population processes, and microenvironmental gradients along ten permanent transects (each consisting of a series of contiguous 10 X 10 m quadrats) established across the typically abrupt and narrow spruce/hardwood ecotone at seven localities in the mountains of eastern central West Virginia and western Virginia. Data obtained for three growing seasons along five transects show that densities and basal areas of trees have exhibited no definite directional shift in position of the ecotone. Densities of hardwood and conifer saplings have displayed slight increases at opposing ends of the transects. Seedling densities, though episodic, evidenced decline for both hardwoods and conifers in the most recent tally. Herbaceous cover has tended to decrease in all segments of the transects. Bryophyte cover has decreased in the hardwood and ecotone segments, but increased somewhat in the conifer segment. Our data at least suggest that red spruce communities in the central Appalachians presently exist in static equilibrium with respect to surrounding hardwoods and exhibit, at some localities, some evidence of advance regeneration into the hardwood communities. (Supported in part by funds provided by the USDA Forest Service.)

CREEPING BENTGRASS AND ANNUAL BLUEGRASS GERMINATION
REPOSE TO PROPICONAZOLE. Bigelow, C. A., R. J. Stipes and D. R.
Chalmers, Virginia Tech, Blacksburg, VA 24061-0331.

Creeping bentgrass (*Agrostis stolonifera* var. *palustris* (Huds.) Farw.) and annual bluegrass (*Poa annua* var. *annua* L.) seeds were tested for their germination response to propiconazole formulations under laboratory conditions. Seeds of both species were germinated in petri dishes at log concns. (0, 1, 10, 100, 1000 ppm) of two propiconazole formulations: a water-based formulation (Alamo) and an organic solvent-based formulation (Banner). At concentrations greater than 100 ppm, both species had significantly less germination percentages than the untreated control or the 1 and 10 ppm solutions of both formulations. At 100 ppm propiconazole there was significantly less germination of seed treated with Alamo compared to those treated with Banner. At concns. of 1000 ppm seed germination of both species was almost inhibited. These tests illustrate that the Alamo formulation seems to be more effective in penetrating seed coats; this might be attributed to a wetting agent or other additives. Propiconazole is an important fungicide in the maintenance of fine quality turfgrass and of ornamental plants and trees. These tests suggest possible explanations of how turfgrass seed germination might be affected when overseeding is done of established turf treated with propiconazole.

VEGETATION OF HIGH-ELEVATION NORTHERN RED OAK (*QUERCUS RUBRA*) FORESTS OF THE CENTRAL VIRGINIA BLUE RIDGE. Philip P. Coulling, Dept. of Biol., Univ. of N.C. at Chapel Hill, Chapel Hill, NC. 27599-3280. Forty-one 0.1-ha vegetation plots in *Quercus rubra* stands \geq 915 m elevation were sampled as part of an ongoing study of the impact of defoliation by gypsy moth on forest understory dynamics. Stands were located in the central Blue Ridge Mountains of Virginia, between the James River and Rockfish Gap, and were distributed over three types of parent material: volcanic (Catoctin metabasalt), plutonic (charnockite), and metasedimentary (Chilhowee Group). In each plot presence and cover estimates of all vascular plant species were recorded in a series of nested quadrats, and diameters of all woody stems \geq 1.3 m in height were measured. Species richness of both trees and herbs was highest on metabasalt sites; herb richness and cover were lowest on metasedimentary sites. A general gradient of decreasing soil fertility occurs from metabasalt to charnockite to metasedimentary rock, although this pattern is not consistent across all sites. Nearly half of the stands on charnockite had herb layers heavily dominated by *Dennstaedtia punctilobula*; charnockite sites with coarser substrate had lower *Dennstaedtia* and total herb cover and higher abundance of composites and deciduous ericads. Contrary to some previous studies in the region, no stands had high importance of *Q. alba*; on flat high-elevation sites *Betula lenta*, *Carya glabra* or *C. ovata* was often secondary in importance to *Q. rubra*. Size distributions typically show a single peak of *Q. rubra* density at 15-30 cm dbh, although a few stands exhibit bimodal size distributions, with a secondary peak at 2.5-5 cm.

DELIVERY OF MACROMOLECULES IN TO INTACT PLANT CELLS VIA PLASMOLYSIS FOLLOWED BY ELECTROPORATION. Carla E. Hegeman & F.S. Wu, Dept. of Biol., Va. Commonwealth Univ., Richmond, Va. 23284. Plant cells can be genetically transformed by electroporation, provided that foreign DNA is in direct contact with the cell membrane. *Glycine max* suspension culture cells were plasmolyzed in various concentrations of sucrose containing plasmid DNA harboring a reporter gene. As the cell membrane pulled away from the cell wall, DNA in the solution was pulled through the pores in the cell wall and accumulated in the void space. This allowed for DNA to contact the cell membrane without removal of the cell wall. Electroporation was then performed to form temporary pores in the cell membrane to allow passage of DNA into the cell. Enzyme assays for the expression of the reporter gene were performed. Higher enzyme activity was detected in cells that received a 0.2 M sucrose pretreatment.

REPRODUCTIVE BIOLOGY OF ARCHAEOPTERID PROGYMNOSPERMS.

Stewart A. Hill and Stephen E. Scheckler, Dept. of Biology, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. The progymnosperms, an extinct group of free-sporing, homosporous or heterosporous plants with gymnospermous secondary tissues from the Middle Devonian to Lower Carboniferous, are considered probable ancestors of seed plants. Recent comparisons of progymnosperms (including Archaeopteridales, Aneurophytales, and Protopityales) to seed plants have been based mainly on vegetative structure. A preliminary assessment will be presented based on reproductive characters of evolutionary hypotheses that specifically link archaeopterid progymnosperms to various seed plant groups. New information pertinent to this question includes general sporangium design, fertile branch construction, spore size distribution, and confirmation that archaeopterids are ancestrally heteropsorous.

PHYTOPLANKTON COMPOSITION IN CHESAPEAKE BAY. H.G. Marshall, Dept. Biological Sciences, Old Dominion Univ., Norfolk, Va. 23529-0266. Based on collections taken over three decades in the Chesapeake Bay, the author has identified 708 phytoplankton taxa. These include 360 Bacillariophyceae, 125 Dinophyceae, 87 Chlorophyceae, 38 Cyanophyceae, 24 Haptophyceae, 22 Euglenophyceae, 22 Chrysophyceae, 17 Cryptophyceae, 9 Prasinophyceae, and 4 Xanthophyceae. Abundance and productivity maxima (3) occurred during late winter-early spring, summer, and early fall through a sequence of successional stages. Greater concentrations and higher productivity is generally associated with the western Bay. The flora is dominated by diatoms throughout the year, being supplemented by phytoflagellates during spring, summer and fall, and by cyanobacteria in summer. Sporadic bloom events have been associated mainly with dinoflagellates during summer and early fall. Eleven toxin producing species were also identified. Supported in part by the Virginia Dept. of Environmental Quality and EPA.

USE OF MULTIMEDIA INSTRUCTION IN BOTANICAL EDUCATION. Michael H. Renfroe, Dept. of Biology, James Madison University, Harrisonburg, VA 22807. The development and availability of multimedia authoring programs is facilitating the presentation of traditional, factual information in the botanical sciences. Multimedia presentations allow incorporation of photographs, audio tracks and video clips. Programs can create instructional modules that can be used as tutorial guides to introduce concepts, methods, and materials prior to students conducting laboratory exercises. Instructional programs can be designed to train students in anatomy and morphology in an interactive fashion. Programs also can operate in a test mode in which students are quizzed, yet have the ability to reveal answers and check their responses. Advantages of multimedia authoring programs include the ability to present information from disparate sources such as microscopic and macroscopic specimens. Specimens can be viewed on different scales and perspectives without having to have various pieces of equipment available to the students. Finally, students may view the programs at their own convenience and as often as they need to master the concepts. Other applications, advantages and disadvantages of multimedia instructional modules will be discussed.

APPRASING THE SPECIES COMPOSITION OF THE DIATOMGENUS PSEUDONITZSCHIA IN THE SOUTHERN CHESAPEAKE BAY. Stephanie Roback and H.G. Marshall, Dept. Biological Sciences, Old Dominion University, Norfolk, Va. 23529-0266.

Pseudonitzschia (Nitzschia) pungens multiseries, a producer of the toxin domoic acid, was reported in the Chesapeake Bay three decades ago by Hasle (1965). The distinction between this species and other members of this genus can only be determined with electron microscopy so separating this species from others in this genus would be unlikely with light microscopy. Using archived water samples from the Chesapeake Bay that go back 20 years, a search was undertaken to determine if this species was still in the Bay. The results indicated three Pseudonitzschia species present in the Bay, but Pseudonitzschia pungens multiseries was not found. Pseudonitzschia pungens pungens has the dominant form over these past two decades, with Pseudonitzschia seriata noted infrequently during the colder months. However, Pseudonitzschia pseudodelicatissima, a newly reported species for the Bay, is in samples dating to the late 1980's. and preliminary results indicate this species is becoming more dominant in the lower Bay, with P. pungens pungens decreasing in comparison. Of note, is that P. pseudodelicatissima has also been reported as a potential domoic acid producer, so it is important to follow any increasing occurrence of this species as a potential toxin producer and nuisance species. Supported in part by the Old Dominion University Research Foundation.

LONG TERM TRENDS OF PHYTOPLANKTON POPULATIONS IN THE SOUTHERN CHESAPEAKE BAY. David Seaborn, M. Weinstein, S. Olek, B. Hiller H.G. Marshall, and R.W. Alden. Dept. Biological Sciences, Old Dominion Univ. Norfolk, Va. 23529-0266.

This study represents one component of the lower Chesapeake Bay Phytoplankton monitoring program in which trend analysis statistics were applied to the data set between 1985-1992. The results indicated twenty-three significant ($p<0.01$) trends. These included a decrease across the entire lower Chesapeake Bay in phytoplankton abundance above and below the pycnocline. There were also trends of decreasing number of taxa, above and below the pycnocline, at all stations during each month from March through October. There were monthly differences in the trends (negative:spring and positive:winter) for diatom abundance below the pycnocline over this time period. Supported by the Virginia Dept. of Environmental Quality and EPA.

THE VIRGINIA PITCHER PLANT BOGS. PART THREE. IS THERE INBREEDING OR OUTBREEDING DEPRESSION IN THE YELLOW PITCHER PLANT SARRACENIA FLAVA L. IN VIRGINIA? Philip M. Sheridan and David Karowe, Dept. of Biol., Va. Commonwealth Univ., Richmond, Va. 23284. The Yellow Pitcher Plant, Sarracenia flava L., is an insectivorous plant restricted to fire maintained wetland ecosystems in southeastern Virginia. Only six scattered sites remain in the state with an average population of thirty-six clumps covering a quarter of an acre each. One site each from Dinwiddie, Prince George and Nansemond Counties was tested for the effect of self-pollination (inbreeding), intra-site and inter-site outcrossing on total seed number, total seed weight and average seed weight. In all sites, self-pollination resulted in significantly lower total seed number and total seed weight. Means for self-pollinated capsules were approximately one-fourth the yield of outcrossed capsules; this suggests strong inbreeding depression in all 3 sites. For Dinwiddie plants however, total seed number was significantly lower for inter- than for intra-site outcrossed capsules but the reverse was observed for Nansemond plants and there was no difference among the Prince George plants. Such a pattern might arise if S. flava populations differed in the extent of adaptation to local site conditions.

"A TREE GROWS IN VIRGINIA." R. Jay Stipes and H. L. Witt, Dept. Plant Pathol., Physiol. and Weed Sci., Virginia Tech, Blacksburg, VA 24061-0331. This paper is a take-off on Betty Smith's 1943 novel, "A Tree Grows in Brooklyn," in which the tree was Ailanthus altissima or "Tree of Heaven." This tree was introduced in 1784, and has since become naturalized, invasive and harmfully competitive with the native tree flora. We conducted a "windshield survey" along roadsides and medians from Christiansburg, VA on Interstate 81 up to Staunton, VA, and thence on Interstate 64 to Richmond. We found it along 33% of the 102 miles of I81, and 27% of the 90 miles of I64. We counted from 9 up to 152 stems per "clump" or "grove" in 10 of them on I81. There is a decline in this dioecious species which may be due to climatological and/or pathogenic stress such as Verticillium wilt, yet to be studied and documented. However, it seems to thrive along these highways because of its "preference" for neutral or alkaline soils, and also because of its seed dissemination by the very heavy vehicular traffic. Because this tree is an invasive exotic, there is concern of its potential to out-compete desirable tree flora, and therefore contribute to the loss of indigenous biodiversity and/or merchantable lumber in the Appalachians.

VASCULAR FLORA OF THE CORROTOMAN RIVER WATERSHED, LANCASTER COUNTY, VIRGINIA. Troy W. Weldy and Donna M. E. Ware. College of William and Mary, Department of Biology, Williamsburg, VA 23187.

A study of the vascular flora of the Corrotoman River watershed, Lancaster County, Virginia has provided a number of additional records to the county's flora. Located at the southeastern tip of the Northern Neck, the study area of 229 square kilometers, is entirely within the inner coastal plain physiographic region. As of May 22nd, 1995, a total of 733 different species have been identified, including 183 county, 39 peninsula, and 1 coastal plain record. Among these, the Virginia Heritage has listed the following as rare within the Commonwealth: *Fleischmannia incarnata* (S2), *Habenaria peramoena* (S2/3C), *Lechea villosa* (S3), *Quercus margareta* (S3), *Sabatia dodecandra* (S3), *Stewartia ovata* (S2), and *Triglochin striatum* (S3). The *Stewartia ovata* population is the "lost" population originally discovered by Winfred Harvey and J.T. Baldwin. The study also includes vegetational analysis of representative forest stands using the Bitterlich-circular-quadrat sampling method and phytogeographic analysis of all documented species.

Chemistry

SYNTHESIS AND SPECTROSCOPIC STUDIES OF LIGAND BINDING ON THE PHOTOPHYSICAL PROPERTIES OF A RHENIUM COMPLEX. Siyoung Ahn*, D. S. Amenta, B. A. DeGraff, Dept. of Chemistry, James Madison Univ., Harrisonburg, VA 22807 and J. A. Mosbo, College of Natural Sciences & Mathematics, Univ. of Central Arkansas, Conway, AR 72035-0001. Preliminary evidence indicates that the photophysical properties of transition metals whose ligands contain crown ethers change upon addition of simple cations. The object of this research was to synthesize, characterize, and study the spectroscopic characteristics of rhenium complexes whose ligands contained a crown ether or a crown model. The substituting ligands were either 4'-isocyanobenzo-15-crown-5 or 3,4-dimethoxyisocyanobenzene. The resulting products were then characterized by NMR, IR, UV/VIS, and emission spectroscopy. The object was to determine what effect the cation binding would have on the luminescence of the rhenium crown ether complexes.

SIMULATION OF DISTANCE DISTRIBUTIONS IN PEPTIDES USING MOLECULAR DYNAMICS. David R. Bevan, Dept. of Biochemistry, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. It is important when applying molecular modeling techniques to validate the computer simulation methods by comparing the results with experimental data. We are using molecular dynamics to study the motional properties of peptides, for which corresponding data are available from fluorescence resonance energy transfer experiments. Using molecular dynamics simulations, we computed the distance distribution between a naphthalene fluorescence energy donor and a dansyl acceptor bound to a peptide consisting of N⁵-(2-hydroxyethyl)-L-glutamyl repeating units. These data were fit to a Gaussian distribution which, under some simulation conditions, is in reasonable agreement with that determined by energy transfer. From these computations, we can begin to determine the simulation conditions under which molecular dynamics will reproduce experimental results. Moreover, the computational methods may provide additional insight into molecular events that occur on a timescale that is not readily accessible experimentally.

SYNTHESES AND SPECTROMETRIC PROPERTIES OF TRIKETONES, PYRIDONES, AND PYRONES. Sandra Boatman and Ellen K. James, Dept. of Chemistry, Hollins College, Roanoke, VA 24020. This research compares the absorption and fluorescence spectra of several 1,3,5-triketones and the 4(1*H*)-pyridones and 4*H*-pyran-4-ones derived from them. The IR spectra of all three kinds of compounds displayed C=O stretch absorbances: triketones, free and intramolecularly H-bonded, and pyridones and pyrones, α - β unsaturated. The UV spectra displayed absorbances typical of pi->pi* and n->pi* transitions. Fluorescence (weak) was observed only for triketones with *p*-methoxyphenyl and 2-naphthyl groups. Pyrones also fluoresced only weakly. Pyridones fluoresced strongly to give single emission maxima when excited at all absorbance maxima for the particular compound.

THE ADSORPTION OF N,N'-DISALICYLIDENE-1,2-PROPANEDIAMINE ON 304 STAINLESS STEEL. C.C. Chusuei, Chemistry Dept., George Mason Univ., Fairfax, VA 22030 and Geocenters Inc., Ft. Washington, MD 20744, J.A. Schreifels*, Chemistry Dept., George Mason Univ., Fairfax, VA 22030 and R.E. Morris*, Chemistry Div., Naval Research Lab., Washington, D.C. 20375-5000. N,N'-disalicylidene-1,2-propanediamine is a jet fuel additive that has been shown to reduce the formation of insoluble gums in fuel tanks and on fuel injector nozzles. X-ray photoelectron spectroscopy (XPS) and temperature programmed desorption (TPD) were used to study the interaction of the additive on oxide and oxide-free 304 stainless steel surfaces. These experiments were undertaken to gain an understanding of how the additive reduces insoluble gum formation on nozzles of jet engines. The temperature of the substrate was varied to simulate operating conditions of an aeroengine. Shifts in the XPS binding energy denoted thermal decomposition. TPD data showed that the molecule decomposed/converted to other species. Redhead activation energies were calculated for the chemisorbed state and the mechanism of its adsorption was studied.

THE SYNTHESIS AND STUDIES OF $(\eta^5C_5H_5)M(CO)_x(CH_2C_6H_3\text{-}15\text{-Crown}\text{-}5)$. Andrew M. Dattelbaum, D. S. Amenta, Dept. of Chemistry, James Madison Univ., Harrisonburg, VA 22807 and J. A. Mosbo, College of Natural Sciences & Mathematics, Univ. of Central Arkansas, Conway, AR 72035-0001. The purpose of this research was to synthesize, characterize and study the reactivity of transition metal complexes whose ligands contain crown ethers. One of the target molecules, $(\eta^5C_5H_5)(CO)_3Mo(CH_2C_6H_3\text{-}15\text{-crown}\text{-}5)$ (1), was prepared from $[(\eta^5C_5H_5)(CO)_3Mo]$ and $C_1CH_2C_6H_3\text{-}15\text{-crown}\text{-}5$ (2). The synthesis of 2 was accomplished from the reaction of 3,4-dihydroxybenzaldehyde with the dichloride of tetraethylene glycol, followed by $NaBH_4$ reduction of the resulting aldehyde to yield 4'-HOCH₂-benzo-15-crown-5. Treatment of this alcohol with thionyl chloride gave the desired 2. All intermediate products have been characterized by NMR spectroscopy. The rate of conversion of 1 into an acyl complex has been studied, in the presence and absence of added Na^+ , using external phosphine ligands.

SYNTHESIS, CHARACTERIZATION, AND REACTIVITY OF THE COMPLEXES $Re_2(\mu\text{-}O_2C\text{-}n\text{-}C_5H_4N)_2X_2(\mu\text{-dppm})_2$ ($n = 3, 4$; $X = Cl, Br$; dppm = $Ph_2PCH_2PPh_2$). Anjana Mitra,* Ying-Qing Yu,* Kimberly R. Kongkasawan,* and Daniel R. Derringer,* Dept. of Chem., Hollins Col., Roanoke, Va. 24020 and Kenton H. Whitmire,* Dept. of Chem., Rice Univ., Houston, Tx 77251. Reactions of $Re_2X_4(\text{dppm})_2$ ($X = Cl, Br$; dppm = $Ph_2PCH_2PPh_2$) with $HO_2C\text{-}n\text{-}C_5H_4N$ ($n = 3, 4$) in refluxing ethanol afford complexes of the type $Re_2(\mu\text{-}O_2C\text{-}n\text{-}C_5H_4N)_2X_2(\mu\text{-dppm})_2$. Relatively short reaction times (< 30 min) yield *trans*- $Re_2(\mu\text{-}O_2C\text{-}n\text{-}C_5H_4N)_2X_2(\mu\text{-dppm})_2$ while longer reaction times (several hours to several days) produce *cis*- $Re_2(\mu\text{-}O_2C\text{-}n\text{-}C_5H_4N)_2X_2(\mu\text{-dppm})_2$. The *trans* species react rapidly with $(C_7H_7)PF_6$ in CH_2Cl_2 at room temperature to produce *trans*- $[Re_2(\mu\text{-}O_2C\text{-}n\text{-}C_5H_4N)_2X_2(\mu\text{-dppm})_2]PF_6$. All of the complexes were characterized by infrared and electronic absorption spectroscopy and cyclic voltammetry, and the diamagnetic complexes, *viz.*, *trans*- $Re_2(\mu\text{-}O_2C\text{-}n\text{-}C_5H_4N)_2X_2(\mu\text{-dppm})_2$ and *cis*- $Re_2(\mu\text{-}O_2C\text{-}n\text{-}C_5H_4N)_2X_2(\mu\text{-dppm})_2$, were further characterized by ¹H and ³¹P{¹H} NMR spectroscopy. One of the complexes, *viz.*, *trans*- $Re_2(\mu\text{-}O_2C\text{-}4\text{-}C_5H_4N)_2X_2(\mu\text{-dppm})_2$ was characterized structurally by X-ray crystallography. (Supported by the Camille and Henry Dreyfus Foundation and the W. M. Keck Foundation.)

DISTANCE GEOMETRY APPROACHES TO THE MOLECULAR CONFORMATION PROBLEM. Steven G. Desjardins, Dept. of Chem., Washington and Lee Univ., Lexington VA 24450. The methods of distance geometry, as discussed by Havel and Crippen, are presented as a way to solve the molecular conformation problem. In these methods, molecules are treated as collections of points and lines subject to a set of geometric constraints, e.g., bond lengths and angles, torsional angles, and non-bonded distances, for which only certain solutions are available. Four points to consider are 1) the number of geometric constraints that are needed to solve for a unique molecular geometry, 2) the inclusion of chirality, 3) the use of empirical geometric information with limited precision, and 4) incorporation of this scheme into an energy minimization algorithm. These points will be discussed in connection with the EMBED algorithm of Havel and Crippen.

METAL OXIDE ASSISTED FLAMELESS COMBUSTION OF METHANOL. Jennifer A. Condon* and Thomas C. DeVore, Dept. of Chemistry, James Madison University, Harrisonburg, VA 22807 Interest in the reaction mechanisms that occur during Chemical Vapor Deposition (CVD) processes has increased during the past decade. Evolved Gas Analysis- Fourier Transform Spectroscopy has been used to investigate the chemical reactions that occur as metal films are generated during the thermal decomposition of metal 2,4-pentanedionato complexes (Metal = Ni, Cu, Zn). Reduction of the metal oxide formed during the initial decomposition by the organic ligand is a main reaction in the production of the metal film. The reduction of nickel oxide films by methanol under CVD conditions indicated that this reaction is 0.5 order in methanol and has an apparent activation energy of 490 ± 10 kJ mol⁻¹. A reaction mechanism that accounts for the reaction order in methanol and this very large activation energy has been developed. The rate limiting step in the mechanism is the thermal decomposition of the metal oxide to form oxygen atoms. The oxygen atoms then rapidly react with organic radicals adsorbed on the surface.

EMPIRICAL MOLECULAR INTERACTION MODEL BASED ON SMALL MOLECULE HYDROPHOBICITY. Glen E. Kellogg & Donald J. Abraham, Dept. Of Med. Chem., VA Commonwealth Univ., Richmond, VA 23298-0540

For several years we have been developing a unique model for bimolecular interactions based on the simple experimental results from water/1-octanal solvent partitioning (Log P). The premise is that the solvent environment in which a molecule (or molecular fragment) is most soluble, when given a choice between polar and non-polar solvents, is not dissimilar from the binding environment that said molecule (or fragment) would seek in a protein receptor. Our model is designed to apply the experimental interaction and thermodynamic information content encoded in Log P to significant and complex problems such as drug binding, intermolecular protein - protein interactions, protein-DNA interactions and protein folding. The presentation will be illustrated by results from recent investigations of hemoglobin subunit interactions and DNA/interactors interactions.

SOLID PHASE MICROEXTRACTION (SPME) DETERMINATIONS OF AROMATIC HYDROCARBONS IN WATER. Emily K. Knick, Thomas N. Gallaher* and James J. Leary, James Madison University, Department of Chemistry, Harrisonburg, VA 22807. Currently the Environmental Protection Agency's (EPA) approved method (524.5) for the determination of volatile organic compounds in water requires the use of purge and trap techniques. The instrumentation for this method is expensive and the analyses are time consuming. For semivolatile compounds, the EPA approved method (625) requires elaborate preconcentration by liquid-liquid extractions using methylene chloride as a solvent. This is a lengthy procedure which generates considerable waste. The EPA and other regulatory agencies are trying to find new methods which minimize the use of solvents and simultaneously yield: lower detection limits, faster analysis times and greater reproducibility. Solid phase microextraction (SPME) is a new solventless technique for sample extraction and concentration which may provide an alternative to some of the current methods. The application of this new technique for determination of benzene, toluene, ethylbenzene and xylenes (BTEX) is presented. Preliminary emphasis has been placed on optimization of the extraction and instrumental parameters.

THE SPECIATION OF HEAVY METALS IN SOILS, SEDIMENTS, AND SLUDGES BY USING D.C. PLASMA ATOMIC EMISSION SPECTROMETRY COUPLED WITH ION CHROMATOGRAPHY. Stephen F. Macha and I.T. Urasa, Department of Chemistry, Hampton University, Hampton, Virginia 23668. There are several drawbacks associated with the successive extraction protocol commonly used in the determination of trace metals in soils, sediments, and sludges. The work described in this paper is an attempt to overcome these shortcomings by applying modern chromatographic and spectroscopic technology to the determination of trace metals in environmental samples. The research is based on the employment of direct current atomic emission spectrometry used in combination with ion chromatography (DCPAES-IC) to provide analytical information on the different forms of metal present in the various steps of the successive extraction protocol. The DCPAES-IC approach provides an additional dimension to the analytical procedure, providing speciation data and allowing the determination of the equilibrium concentrations and kinetics of the extraction process.

THE SYNTHESIS AND STUDIES OF AN ISOCYANO-ETHYL-SUBSTITUTED CROWN ETHER AND ITS TRANSITION METAL COMPLEX. Jill M. McFadden*, D. S. Amenta, Dept. of Chemistry, James Madison Univ., Harrisonburg, VA 22807 and J. A. Mosbo, College of Natural Sciences & Mathematics, Univ. of Central Arkansas, Conway, AR 72035-0001. When crown ethers are bound to a transition metal, the addition of a metal cation, such as Na^+ or K^+ , may substantially affect the catalytic properties of the complexes. In order to study these effects, crown ethers must first be synthesized which have groups such as the isocyanide function that can ligate to the transitional metal. Synthesis of the target ligand 4'-(2-isocyanoethyl)-benzo-15-crown-5 was undertaken from the corresponding formamide. The latter compound was obtained from the hydrogen bromide of dopamine. Synthesis of a transition metal complex was accomplished. All compounds have been characterized by IR and NMR spectroscopy.

SYNTHESIS AND CHARACTERIZATION OF POLYIMIDES PREPARED VIA DIELS-ALDER REACTION BETWEEN 3,3'-(OXYDI-*p*-PHENYLENE)BIS(2,4,5-TRIPHENYL-CYCLOPENTADIENONE) AND VARIOUS BISACETYLENES. Rooma M. Mehta and R.G. Bass, Dept. of Chemistry, Box 842006, Virginia Commonwealth Univ., Richmond, VA 23284-2006. As part of a program to develop high performance/high temperature polymers for potential use as composites and adhesives in various aerospace applications, a series of polyimides were prepared via the Diels-Alder reaction between 3,3'-(oxydi-*p*-phenylene)bis(2,4,5-triphenylcyclopentadienone) and various bisacetylenes having preformed imide units. This process of polymerization does not require the formation of a polyamic acid, thereby eliminating the processing disadvantages associated with the state of the art polyimides. In addition, the reaction yields phenylated benzene units along the polymer backbone, thus imparting solubility to these polymers. Polyimides of medium to high molecular weight were prepared as evidenced by inherent viscosities ranging from 0.43 - 1.08 dL/g, obtained on 0.5% (w/v) solutions in chloroform at 25 °C. The polymers prepared were soluble in a number of common organic solvents including chloroform, toluene, dimethylsulfoxide, 1-methyl-2-pyrrolidinone and dimethylacetamide. Yellow fingernail creasable films of these polymers can be cast from chloroform solutions. These polymers exhibited glass transition temperatures ranging from 260 - 334 °C. The thermal stability of these polymers was excellent as evidenced by 10% weight loss in air at temperatures >499 °C and in helium at temperatures >523 °C.

MESSENGER RNA CAP ANALOGS AS SUBSTRATES FOR THE GUANINE-7-METHYLTRANSFERASE. Jason Napodano, D. M. Sinagra, and T. O. Sitz, Dept. of Biochem., Virginia Tech, Blacksburg, VA 24061. Guanine-7-methyltransferase that methylates the cap structure in mRNA, can use the symmetric cap analog GpppG as a substrate. Earlier work in our laboratory demonstrated that another cap analog, GpppA, was not a substrate. Recently, by HPLC analysis, we found that this material was not GpppA but some other nucleotide, which explains why it was not a substrate for our enzyme. This analog was not a substrate for *in vitro* transcription. Another lot number of GpppA was resistant to alkaline phosphatase digestion and had a characteristic elution profile on HPLC. This new lot of GpppA was a substrate for the guanine-7-methyltransferase, however its Km was 14-fold higher than the Km for GpppG. This GpppA was incorporated into RNA made in a T7 RNA polymerase *in vitro* transcription system. Currently we are characterizing the ability of these transcripts to serve as substrates for the cap methyltransferase.

DEVELOPMENT OF A SWIPE TEST FOR DETECTING ILLICIT DRUGS ON SURFACES. Grazyna E. Orzechowska, Edward J. Poziomek, and Julie C. Patrick Department of Chemistry and Biochemistry, Old Dominion University, Norfolk, VA 23529-0126. Achieving efficiency in sampling and avoiding losses in sample handling are integral to the operation of field detection and analytical systems. We have been designing sampling procedures as part of the development and evaluation of a prototype sensor system for cocaine hydrochloride. The present paper focuses on development of a swipe test for cocaine hydrochloride, though the same procedure should be applicable to heroin hydrochloride, other illicit drugs, and contaminants in scenarios other than those related to drug interdiction. A variety of swipe materials were used to study efficiency of transfer from several types of surfaces. We also examined effects of transfer from swipe gloves to sensor sample tickets. Tests were designed to simulate the surface targets typically encountered in the field. Metal surfaces, of different composition and surface roughness, were contaminated with illicit-drug simulants and sampled using dry and wet swipes. On the basis of the results to date, it was concluded that Teflon is the most versatile material as both a swipe fabric and as a sensor ticket matrix. However, there are trade-offs. These will be discussed. The authors gratefully acknowledge support from the Advanced Research Projects Agency through a subcontract from Battelle, and review by James A. Petrousky, Office of Special Technology, Fort Washington, MD.

SYNTHESIS AND CHARACTERIZATION OF $[Re(dppm)_3]^+$. John Overacker,* Kimberly R. Kongkasawan,* and Daniel R. Derringer,* Dept. of Chem., Hollins Col., Roanoke, Va. 24020 and Kenton H. Whitmire,* Dept. of Chem., Rice Univ., Houston, Tx 77251. Complexes of rhenium(I) are relatively rare, and homoleptic complexes containing three chelating bis(diphenylphosphino)methane (dppm) ligands are almost nonexistent. Here we report two compounds, $[Re(dppm)_3]ReO_4$ and $[Re(dppm)_3]PF_6$, both of which contain the new tris[bis(diphenylphosphino)methane]rhenium(I) cation. The perrhenate salt was synthesized from $Re_2Br_4(dppm)_2$ unintentionally, while $[Re(dppm)_3]PF_6$ was prepared by reacting $ReCl(N_2)(dppm)_2$ with dppm and KPF_6 in methylene chloride at room temperature. Both of the new compounds were characterized by infrared and electronic absorption spectroscopy, and $[Re(dppm)_3]ReO_4$ was characterized structurally by X-ray crystallography. (Supported by the Camille and Henry Dreyfus Foundation and the W. M. Keck Foundation.)

STUDIES ON SIMULANTS FOR ILLICIT DRUG INVESTIGATIONS. Julie C. Patrick, Edward J. Poziomek, and Grazyna E. Orzechowska, Department of Chemistry and Biochemistry, Old Dominion University, Norfolk, VA 23529-0126. Technological challenges in development and testing of field analytical methods for illicit drugs such as cocaine hydrochloride (HCl) and heroin-HCl, include assuring safety of researchers and operations personnel from exposure to the drugs, assessing the efficiency of sampling and sample handling in a simple but quantitative manner, checking for artifacts introduced by field procedures, and identifying a spike other than the target drug for quality control/quality assurance purposes. Methylene blue was chosen as a simulant for *both* cocaine-HCl and heroin-HCl to help meet these challenges. The similarities include molecular weights over 300, melting points between 200 and 300°C, solubility in water, alcohol, and chloroform, and insolubility in ether. Also, all three of the compounds are chloride salts. The major difference is that methylene blue is highly colored whereas cocaine-HCl and heroin-HCl are colorless. It is estimated that as little as 10^{-8} moles (3.1 µg) of the dye covering a surface of 10-30 cm² can be seen under ideal conditions. This will be very useful in the visual assessment of sampling efficiency and in operator training. The authors gratefully acknowledge support from the Advanced Research Projects Agency through a subcontract from Battelle, and review by James A. Petrousky, Office of Special Technology, Fort Washington, MD.

THE CHARACTERIZATION OF DENSE CERAMIC MEMBRANES FOR THE PARTIAL OXYGENATION OF METHANE TO SYNGAS. Michelle L. Radloff, Dept. of Chem., Mary Baldwin Col., Staunton, VA. There are large reserves of natural gas, consisting primarily of methane, which can be useful when a ceramic membrane is used to convert the methane to syngas. This ceramic membrane allows only oxygen to permeate into the core, where it can react with methane and oxidize the methane to syngas(CO and H₂). My research attempts to find a material which exhibits the maximized properties that are desired for a ceramic membrane, such as high strength and high oxygen selectivity. Several materials, including SFC-2, a Strontium-Iron-Cobalt-Oxide, and a Sr-Fe-Ox powder with cobalt added as a metal, were tested. The sample preparation factors that were varied were the pressure at which the bars were pressed, the firing temperature, and the firing atmosphere. Both bars and tubes of these materials were tested and the results were compared. Although the ideal material and conditions have still not been discovered, much progress has been made towards the discovery of a strong, yet oxygen-specific permeable membrane.

AB INITIO STUDY OF THE TRANSITION STATE OF THE UNIMOLECULAR DECAY OF CHLOROFORMIC ACID. Christopher B. Schultz and D. D. Shillady, Dept. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23298
The GAMESS *ab initio* electronic structure program has been used to carry out a study of the transition state of the unimolecular decomposition of trans-chloroformic acid to HCl and CO₂. Saddle-point optimization of the transition state with a 6-31G** basis set indicates an activation energy of 6.98 Kcal/mole. Graphs are presented showing the energy of the molecule as a function of the rotation of the C-O-H plane from trans- to cis- where Pimentel has documented the formation of HCl and CO₂.

ANALYSIS OF ALKALINE STABLE RNA STRUCTURES ISOLATED FROM THE ARCHAEBACTERIUM *SULFOLOBUS SOLFATARIIUS*. D. M. Sinagra, K. A. Oxenrider, and T. O. Sitz, Dept. of Biochem., Virginia Tech, Blacksburg, VA 24061. Messenger RNAs (mRNA) from archaebacteria do not have a classical "Shine-Dalgarno Sequence" (-AGGAGGU-) which is complementary to the 3'-end of 16S rRNA. The archaebacteria *Sulfolobus solfataricus* may be closely related to eucaryotes (eocytes). The examination of 30 *Sulfolobus* mRNA sequences in Gene Bank did not find any consensus sequence complementary to the 3'-end of 16S rRNA or any other consensus sequence. It is not clear how ribosomes bind to mRNA in *Sulfolobus*. Are the "cap" structures found in eucaryotes also found in *Sulfolobus* mRNA? Whole cell RNA from *Sulfolobus solfataricus* was digested with 0.3N NaOH. Alkaline resistant fragments were isolated and then digested with alkaline phosphatase and apyrase for 30 min. at 37°C. This digest was applied to a Gen-Pak FAX column on HPLC and a single undigested peak was observed. The undigested peak material was digested with venom phosphodiesterase and apyrase and analyzed with a Hamilton PRP-X100 Anion exchange column on HPLC; again, only a single peak was found. The significance of these digestion data will be discussed.

REFLECTIVE POLYIMIDE FILMS VIA *IN SITU* METALLIZATION. Robin E. Southward, D. Scott Thompson, D. W. Thompson, Maggie L. Caplan and A. K. St. Clair, Department of Chemistry and Applied Science Program, College of William and Mary, Williamsburg, VA 23187 and Langley Research Center, National Aeronautics and Space Administration, Hampton, VA 23665-5225. Optically reflective mirrors with polymeric rather than glass supports can reduce weight and fragility. Silver has a high reflectivity coefficient in the visible region of the EM spectrum. We report studies on a single stage (*in situ*) metallization of BTDA/4,4'-ODA films using (1,1,1,5,5,5-hexafluoro-2,4-pentadionato)silver(I) as the source of metallic silver. This complex is formed *in situ* by the reaction of silver acetate or fluoride with the parent beta-diketone. In thermal curing of silver(I)-containing BTDA/4,4'-ODA poly(amic acid) films silver is reduced to the metallic state and migrates to the air side surface of the polyimide. The silvered surfaces have excellent reflectivity and mechanical properties and acceptable thermal stability. The adhesion of silver to the polymer is excellent and appears to be due to both mechanical interlocking and the formation of silver-carboxylate interactions. Several other solubilizing ligands and additional soluble silver(I) compounds were investigated which also gave reflective metallized surfaces and some surface conductive films.

SYNTHESIS AND PYROLYSIS OF ALKYL PYRIDINES AND QUINOLINES. Wayne M. Stalick, Joseph Murray, Nazdandeh Zahadat and Nazi Abousaeedi*, Dept. of Chemistry, George Mason University, Fairfax, VA, 22030. Fuel instability studies have implicated short alkyl chain substituted heterocycles as major reactants. Two types of instability have been studied: short-term high temperature (oxidative instability) and long-term low temperature (storage instability). Nitrogen containing heterocycles have been implicated in both types of instability. The variation in types of heterocycles and concentration in different fuels makes model compound studies attractive. Precursors to these short chain compounds are branched and long chain alkyl substituted cyclic or aromatic compounds that are degraded during thermal refining. Two classes of compounds were synthesized and then pyrolyzed: 2, 3, and 4-pentadecyl pyridine; and 2 and 4-undecyl quinoline. The syntheses were all performed in liquid ammonia using a modified Brown and Murphy procedure, a reaction which didn't work to produce 3-undecyl quinoline. The purified alkylaromatics were pyrolyzed at temperature and pressure conditions similar to delayed coking. Free radical attack at the alpha and gamma positions in the side chain was favored; however, an interesting aryl-alkyl bond cleavage occurred in the quinoline series which had not been noted in our previous pyrolysis studies.

CONTROL OF THERMAL EXPANSION COEFFICIENTS IN POLYIMIDE FILMS.

Anne K. St. Clair, Robin E. Southward, and David W. Thompson (NASA Langley Research Center, Hampton, VA 23681. The addition of lanthanide compounds to the 2,2-bis(3,4-dicarboxyphenyl)hexafluoropropane dianhydride/1,3-bis(aminophenoxy)-benzene polymer (6FDA/APB) in DMAc (both in the amic acid and imide forms) to achieve a homogeneous and optically transparent distribution of Ln(III) ions throughout the polymer has been studied. The Ln elements are unique in giving a series of ions with a trivalent oxidation state and uniform variation in +3 radii from 117 to 84 pm. Lanthanide(III) acetates solubilized and coordinated with the dibenzoylmethane, hexafluoroacetylacetone, trifluoroacetylacetone, and trifluoroacetic acid have been incorporated into transparent 6FDA/APB films. X-ray and TEM data are consistent with particle sizes for the lanthanide ion containing species which are in the nanometer range. The effect of various Ln additives on T_g , thermal stability, the coefficient of thermal expansion, and mechanical properties will be discussed. In selected cases the CTE was lowered by as much as 25 percent while the thermal and mechanical properties of the films remained intact.

EFFECTS OF SURFACTANTS ON COLORIMETRIC DETERMINATION OF NICKEL

AND COBALT. Michael J. Tutor, Daniel Y. Pharr and Frank A. Settle, Jr., Department of Chemistry, Virginia Military Institute, Lexington, VA 24450-0304. In an attempt to automate the spectrophotometric determination of cobalt and nickel the nonionic surfactant Triton-X 100 was used to catalyze the complex formation of cobalt and nickel with 4-(2-pyridylazo)resorcinol. Triton-X 100 was successful in catalyzing the reaction and eliminating heating and waiting periods that would not allow the use of Flow Injection Analysis as a method of determination.

MAGNETIC CIRCULAR DICHROISM AND AB INITIO STUDY OF MELATONIN

Anthony Viol, Charles Castevens and D. D. Shillady, Dept. of

Chemistry, Va. Commonwealth University, Richmond, Va. 23298

Melatonin is a female hormone whose function has been implicated as abnormally effected by 60 Hz EMF leading to breast cancer in female electrical workers by Loomis at Duke University. Magnetic circular dichroism spectroscopy indicates melatonin has a large magnetic transition at about 300 nm similar to the 290 nm MCD peak of serotonin previously studied in this laboratory. The GAMESS *ab initio* electronic structure program has been used to optimize the geometry of melatonin at the STO4G basis level and CNDO/2-D excited states have been used to assign the magnetic transition moment.

THE WETTABILITY OF ROUGH SUBSTRATES BY VISCOUS POLYMER MELTS.

S. A. Tschetter, N. E. Shephard & J. P. Wightman, Dept. of Chemistry, Va. Tech., Blacksburg, Va. 24061. Wetting has long been recognized as a necessary but insufficient criterion for good adhesion, but little work has been reported on quantitative studies of wetting by neat polymers. Preliminary studies have demonstrated the feasibility of using model porous substrates to study, the flow of neat polymers into capillaries. In this study, the substrate and polymer were allowed to equilibrate at the test temperature before coming in contact with each other. The extent of polymer flow into the capillaries was assessed by dissolving the porous substrate and measuring the length of the resultant polymer fibrils from scanning electron photomicrographs. The polymer flow experiments were made as a function of time and temperature using polystyrene of various molecular weights including some above and below its chain entanglement length. [Research supported by Center for Adhesive and Sealant Science]

A COMPUTER INTERFACE TO PREDICT AND COMPARE INFRARED SPECTRA

Robert H. Williams and (Frank A. Palocsay), Department of Chemistry, James Madison University, Harrisonburg, VA 22807. The goal of this project was to develop a user friendly interface that would allow students and instructors to compare the peak heights and locations of two infrared spectra. This interface program was written in *Visual BASIC for Windows* a computer language developed and sold by Microsoft, Inc.. The spectra to be compared can be: predicted by a molecular modeling program such as *HyperChem*, experimentally determined or a combination of these depending on the purpose of the exerciset. By comparing two predicted or sample spectra a student sees how the infrared spectrum changes as a result of changes made to a molecule. Comparison of a sample spectrum and a predicted spectrum can be used to aid in identifying compounds and in showing the limitations of current modeling techniques. PM3, the premiere algorithm used for calculating vibrational spectra, often has an error of 10 percent or more. Thus, we have also analyzed the feasibility of using *Visual BASIC* and Ward Systems' *NeuroWindows* DLL to implement an artificial neural network program which will refine the spectrum predicted by the PM3 algorithm.

SURFACE MODIFICATION OF GLASS BEADS AND SILICON PARTICLES. R. Yin, R. M. Ottenbrite, Dept. of Chem., Va. Commonwealth Univ., Richmond, Va. 23284. Surface modification of glass beads was achieved by two approaches, graft polymerization of acrylic acid and dendritic process. The optimum reaction conditions such as solvent, temperature and the concentrations of the initiator, monomer and glass beads were determined to effectively graft poly(acrylic acid) onto the glass beads. It was found out that AIBN is as effective as BPO in the graft polymerization of acrylic acid if suitable reaction conditions were chosen. In contrast with the polymer grafting, a dendritic-modified procedure provided high grafting percentage by a step-wise strategy. The glass beads were used as a "starburst core", and a uniform fractal molecular structures were formed on glass via the "divergent generation" growth. It was difficult to achieve 100% conversion at any generation during the dendritic process, and an alternating high/low conversion was found for consecutive generations. The surface properties of the modified glass depended on the molecular structure of terminal generation. Surface modification of methyl polysiloxane particle was proceeded via photo initiating chlorination, NH₂ replacement, and functionalization.

HYDROPHOBIC DERIVATIZATION OF ANIONIC POLYMERS FOR ENHANCED BIOLOGICAL ACTIVITY. Syed Imran Zaidi and R. M. Ottenbrite, Dept. of Chem., Virginia Commonwealth Univ., Richmond, VA 23284-2006. The monomer (2-propenyl)benzene-3,4-diacetate was synthesized from safrole by ring opening followed by the protection of dihydroxyl groups by acetylation. The polymer poly(maleic anhydride-co-(2-propenyl)benzene-3,4-diacetate) was synthesized by free radical copolymerization of maleic anhydride and (2-propenyl)benzene-3,4-diacetate. The copolymerization reaction was studied in detail to optimize the reaction conditions and to obtain controlled molecular weight polymers with the narrow polydispersity. Several alkyl amines were grafted to the polymer to enhance the biological activity of these polymers.

SYNTHESIS OF OLIGOPEPTIDES FOR ORAL DRUG DELIVERY. Ruifeng Zhao and R.M.Ottenbrite, Dept. of Chem., Va. Commonwealth Univ., Richmond, Va. 23284-2006. Recently, proteinoid materials have been used successfully for oral drug delivery of polysaccharide and protein drugs. The basis of this technology is that these proteinoids can form microspheres with the drug at pH 1-3 and that these microspheres only dissociate at higher pH. Therefore, the trapped drug in the microspheres is protected from the hostile enviroment in the stomach (pH 1-2 and high concentration of enzymes) but release the drug in the upper GI tract at pH 7. More recently, *in vivo* and *in vitro* tests indicate that complexes between the drug and proteinoids are formed and these complexes enhance the drug transport through membrane. To prove this mechanism, specific oligopeptides were synthesized and characterized. The microsphere formation and complexation studies of these oligopeptides with specific drugs are currently being investigated.

Computer Science

APPLICATION OF BACKPROPAGATION FEEDFORWARD NEURAL NETWORK CREATED WITH MATHEMATICA. Angela R. Alexander and Lawrence R. Daley, Department of Computer Science, Hampton University, Hampton, Virginia, 23668. Neural networks are mathematical computer-based simulations of the living nervous system. Neural networks have become an innovative topic in computer science research. Neural networks are used in all aspects of science, liberal arts, business and industry, and medical research. The main idea behind neural networks is getting the computer to simulate the thought process, instead of the computer being programmed to routinely perform. Mathematica(c), a commercial software package, is used in creating this backpropagation feedforward network. This paper will present background information on neural networks in general, and backpropagation feedforward networks in particular. We will also present an actual application of the backpropagation feedforward neural network. (Supported by Office of Naval Research)

MAKING AN INTELLIGENT ABSTRACT DATA TYPE INTELLIGENT. Tara N. Butler, Hampton Univ., Hampton, Va. 23668. This presentation will focus on the concept and implementation of Intelligent Abstract Data Types (IADT's). An IADT is an abstract data type which carries the properties of encapsulation and also runs concurrently with its clients. The driving force behind the concept of using IADT's, is that is possible to create ADT's with a form of intelligence. This intelligence is shown through the IADT's "knowledge" of when to modify its own behavior through the use of a variety of internal functions. IADT's can also use their intelligence to change their structure if necessary, perhaps from a linked list to an array. Specifically, it is that ability which was tested. An unbounded list will begin to carry out a variety of operations, among them Insert and Delete. A history of operations will be maintained and when the number of Inserts/Deletes is equal to a certain percentage of the last "n" operations the unbounded list will "intelligently" switch to a bounded list, or an array. (Supported by the Office of Naval Research).

THE EFFECT OF TOPOLOGY AND PROTOCOL SELECTION ON LOCAL AREA NETWORKS. Ben J. Fornshell and Rita M. D'Arcangelis, Department of Computer Science, Mary Washington College, Fredericksburg, VA 22401. The topology of a computer network defines not only its geographical layout, but also influences the effectiveness of the network. The language that a network uses to communicate is called a protocol. Protocols, which define how messages are packaged and how they are communicated across the network, also affect network performance. A study has been undertaken to simulate the operation of both token passing and Carrier Sense Multiple Access/Collision Detection (CSMA/CD) communication protocols on Star Bus and Ring Bus network topologies, with and without switching, in order to compare their performances under a variety of conditions, including changes in packet size, number of transmitting nodes, hub buffer size, and network load. The architectures of the various models used are described, the phases of the simulation are explained, and an analysis of the results in terms of response time and throughput is presented. Implications for the design of optimal networks are discussed.

APPLICATION OF A HOPFIELD NEURAL NETWORK CREATED WITH MATHEMATICA. Demetrius Shaffer, Hampton Univ., Hampton, VA, 23668, & Lawrence R.

Daley, Dept. of Comp. Sci., Hampton Univ., Hampton, VA, 23668. The human brain is thought to rely on massive parallelism among neurons. This enables data transfer to occur in a parallel fashion rather than a sequential fashion. This parallelism cannot be derived from computationally sequential algorithms and programs. The notion of computers mimicking the functions of neurons can be implemented by the use of neural networks. A neural network steps away from sequential algorithms, where information is processed one step at a time, and tries to simulate the parallelism of the human brain to process information all at once. In this paper, we present the key concepts of neural networks and we also demonstrate an application of the Discrete Hopfield network architecture that was created using Mathematica(c). (Supported by the Office of Naval Research grant for Student Enhancement in Mathematics and Sciences.)

CHALLENGES OF IMPLEMENTING A CONCURRENT PROGRAM ON A DISTRIBUTED SYSTEM. Suijuan Upshaw, Hampton Univ., Hampton, VA, 23668, & Robert Willis,

Dept. of Comp. Sci., Hampton Univ., Hampton, VA, 23668. In order to achieve the theoretical speedup gained through concurrency, concurrent processes must be sent to a distributed system. In order to discover the level of difficulty associated with this procedure, a concurrent Ada program was transformed onto a distributed program. This new program was then implemented on NeXT machines using Zilla, an application which volunteers machines in a common network to participate in parallel computation. Two inherent problems in the transformation were protecting the critical sections from simultaneous access, and devising a means of communication among the distributed processes. Research was hindered by unexpected problems in learning idiosyncrasies of the Zilla application. (Supported by the Office of Naval Research grant for Student Enhancement in Mathematics and Sciences.)

DISPLAY AND STATIC LINKS: A STUDY OF SCOPE IMPLEMENTATION IN PASCAL. Frank Wang, & John Rabung, Dept. of CS, Randolph-Macon Col., Ashland, Va. 23005. In

implementing block structured languages like Pascal, compiler designers often choose the so called "display" mechanism over the more conventional "static links" for reasons of "efficiency" in accessing information stored in higher level blocks. In our study, we tested this practice by modifying *UVAPC*, a Pascal compiler which was developed by the University of Virginia and which uses the display approach, to implement static links. We then compared the cost of using either method in SUN4 environment, and performed various tests on many Pascal programs to assess different aspects of scope accesses. Contrary to common belief, we found that static links work better in most scope access operations than a display does. Also the fact that programs written by students seldom access information from more than one level away made us believe that the static links method is a better choice for scope implementation.

Education

KNOWLEDGE OF THE HUMAN REPRODUCTIVE SYSTEM BY STUDENTS ENTERING A COLLEGE BIOLOGY COURSE: 1992 AND 1995. H. S. Adams, D. S. Lancaster Cmnty. Col., Clifton Forge, VA 24422. All students enrolled in the general biology class at Dabney S. Lancaster Community College in January, 1992 (n=51) and 1995 (n=48), were assessed for knowledge of the human reproductive system. Twenty-five questions dealt with male and twenty-five with female anatomy and physiology. Additionally, students were asked to rank order five methods of contraception, from most to least effective. Overall score of the 1995 group was five percentage points higher than that of 1992, with most gain made on the male reproductive system (nine points). In both years, female respondents averaged three to four percentage points higher than males overall. From 1992 to 1995, male knowledge of female systems improved by seven percentage points and female knowledge of male systems increased by eleven percentage points. Abstinence, the female oral pill, and the male condom were the most frequently mentioned methods of contraception by both sexes in both classes, although the 1995 students named a greater variety of contraceptives than did those in 1992. In summary, it would seem that students entering general biology in 1995 generally were more knowledgeable of the human reproductive system than those in 1992.

ANALYTICAL MULTIPLE CHOICE QUESTIONS: DO THEY BENEFIT STUDENTS? H. S. Adams, D. S. Lancaster Cmnty. Col., Clifton Forge, VA 24422. For the past two years, the relationship between the kind of weekly review exercise completed by students and student achievement has been assessed. Students attending a single lecture section in human anatomy and physiology and in general biology were divided into two lab sections in each course. Students in both lab sections of each course covered the same basic material and received two types of exercises, but were required to submit responses to only one type for grading. Students in one lab section submitted answers to factually-oriented questions (e.g., fill-in, true-false, matching, short-answer essay). Students in the alternate lab section submitted answers to analytical multiple choice questions intended to develop analytical thinking skills. Scores for these questions, tests, and any other graded material, as well as grades for the course, were compared for the two groups in the two courses. Where possible, grades in courses taken the following year were compared between groups. Although based on small sample sizes, results generally suggest that students completing the analytical multiple choice exercises have achieved at a higher level than students completing factually-oriented exercises.

DETERMINING STUDENT LEARNING STRATEGIES FOR THE INVESTIGATIVE STUDY OF BIOLOGY Diah Aryulina and Thomas G. Teates, Div. of Curriculum and Instruction, Va. Polytechnic Institute and State Univ., Blacksburg, VA 24061 - 0313. The use of investigative laboratory problems is one of the recommended methods of instruction for improving the outcomes of college science laboratory work. Much research has examined students' achievement or thinking development in science laboratories, but little research has been conducted to examine learning strategies students use in this setting. During fall semester, 1994, a study involving interviews with ten students who were taking an introductory biology laboratory was conducted at Virginia Tech. Qualitative analyses of field notes and transcripts of the interviews were used to identify the several types of learning and the primary learning strategies used by the students. Four learning themes and three learning strategies were identified.

ELEMENTARY SCIENCE EDUCATION REFORM IN AUSTRALIAN AND NEW ZEALAND PUBLIC SCHOOLS. Michael L. Bentley, Dept. of Science Education, National-Louis Univ., Evanston, IL 60201. Schools in Australia and New Zealand have been involved in a broad-based educational reform movement which includes revising the science curriculum. In both countries, many "primary" (K-6) schools are developing integrated and interdisciplinary programs in which the curriculum begins with children's interests and is developed through language-based and inquiry instructional strategies. In this approach, the teaching of science is characterized by text-rich classroom environments designed to engage children in educationally meaningful activities. The chief aim is that children retain their curiosity about the natural world while developing scientific understandings. Examples of practice in Australian and New Zealand schools will be shared and participants will be introduced to *Science Alive*, a new international core science program from "down under."

SPREADING THE WORD: DEVELOPMENT OF THE DANVILLE SCIENCE CENTER. Elizabeth Blatt, Eugene Maurakis, and Walter Witschey, Science Museum of Virginia, 2500 West Broad Street, Richmond, VA 23220. The Danville Science Center, a division of the Science Museum of Virginia, was developed through the combined efforts of local community organizations, City of Danville, and Science Museum of Virginia to promote science education through informal science methods for southside Virginia. The interactive hands-on science center will house three exhibition theme areas: Fundamentals of Science (e.g. Light and Vision, and Forces and Motion, Tour the Solar System, Electricity, Crystals), Local Science (e.g. natural history of the Dan River, textiles, rubber), and Visiting Science Exhibitions (Harvesting the Sun). Educational programs linked to the interactive exhibitions include: daily school group tours, science after school programs, teacher training and workshops, staff and volunteer training seminars, Science-by-Van, Airmobile, and Science-to-Go kits for classroom use. Additional science educational programs planned for the community at large are: summer science explorers programs, special science events during festival weekends, science camp-ins, skywatch, teacher conferences, and resource dissemination through the Science Museum's *Center for Science Education*.

V-QUEST REFORM EFFORTS: INVESTIGATIVE BIOLOGY AT THE UNDERGRADUATE LEVEL, George E. Glasson & Woodrow McKenzie, Div. of Curriculum & Instruction, Virginia Tech, Blacksburg, VA 24061-0313. Presenters will share findings from a multi-media authentic assessment program which documents the progress of a project designed to reform how undergraduate biology is taught. The goal of the reformed curriculum was to engage freshman biology students in investigative learning in which they worked collaboratively to design their own experiments. Through videotaped excerpts of laboratory instruction and interviews of the professor, graduate teaching assistants, and students, we found that faculty and students were actively engaged in risk-taking and decision-making. Examples of student work demonstrate that students were successful in designing experiments to investigate variables involved in fermentation. (Supported by NSF # OSR 920058)

A COMPARISON OF FOUR CONTEMPORARY SCIENCE EDUCATION INITIATIVES. Tanya K. Grace, Kristen A. Anonick, Mary C. H. Weller, Joy R. Woodruff, Enza J. McCauley, & Barry R. Thompson, Curry School of Education, Univ. of Va., Charlottesville, Va. 22904. Several science education initiatives have been recently proposed in response to current trends in American education. We conducted a comparative analysis of the National Science Education Standards, Project 2061 Benchmarks for Science Literacy, Scope, Sequence and Coordination of Secondary School Science, and the Virginia Science Standards of Learning. Comparisons were made across these four documents in content, process, goals, philosophy, and application to science curriculum reform. The National Science Education Standards served as a baseline for comparison in our research. Matrix format was used to compare content for life science, physical science, and general science topics. Process, teaching strategies, and philosophies were analyzed using charts of comparison. Our findings show similarities among the documents in terms of science content. Each document generally contains the same concepts, yet each has a varying degree of specificity and breadth of content coverage. Major differences were found among the documents in terms of teaching methods and educational philosophies. (Sponsored by Ertle Thompson, University of Virginia)

ENCOURAGING SECONDARY SCIENCE TEACHERS TO IMPLEMENT A GREATER VARIETY OF WRITING BY THEIR STUDENTS. Kenneth S. Lawwill, Chantilly High School, 4201 Stringfellow Road, Chantilly, VA, 22021 and Thomas G. Teates, Div. of Curr. & Inst., 305 War Memorial Hall, VPISU, Blacksburg, VA, 24061-0313. This study is an in-depth documentation and evaluation of the Chantilly High School Science Department's voluntary workshop effort to introduce and utilize several writing to learn strategies. Data from student and teacher surveys, ongoing interviews, and writing samples will be discussed as well as the strategies. .

V-QUEST REFORM EFFORTS:INTERDISCIPLINARY SCIENCE AND MATH AT THE SECONDARY LEVEL, Woodrow L. McKenzie & George E. Glasson, Div. of Curriculum & Instruction, VA Tech, Blacksburg, VA 24061-0313. Presenters will share findings from a multimedia authentic assessment program which documents the efforts of an Algebra Teacher and an Earth Science Teacher to integrate aspects of their curriculum with a relevant environmental problem local to their school district. Their collaboration with each other and other professionals is presented with an assortment of data from students that highlights their exemplary efforts. Included are video clips of actual instruction, examples of student labwork, spreadsheets, journal entries, and interview data that help in the synthesis of our own assessment efforts. From this data, we conclude that through concerted effort, interdisciplinary efforts at the secondary level can be quite successful by engaging students in relevant projects that require skills that span disciplines.

MATH AND SCIENCE REFORM CONCERN'S OF SOME RURAL VIRGINIA SCHOOLS, Thomas G. Teates, Department of Curriculum and Instruction, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0313. To obtain baseline data in preparation for a three-day workshop designed to enable six small rural school divisions to select and implement desired school science and math curriculum and instructional changes, a questionnaire was designed to obtain information about participants' knowledge of previous reform "products" and current concerns about reform needs. Results of the survey, including sampling of elementary and secondary science teachers in some of the school divisions in addition to the workshop participants, indicate that there is extensive lack of awareness about or experience with most of the curriculum products of the previous reform efforts in science and math. There is also widespread lack of teacher awareness of the current national and state curriculum reform efforts. There is awareness of the need to reform local school programs, and a belief that teachers should be directly involved with the effort.

A HISTORY OF SCIENCE EDUCATION AS SEEN THROUGH ADVERTISING.
Pamela C. Turpin, Chemistry Dept., Roanoke College, Salem, Va. 24153-3794. Can advertisements give us an accurate picture of what science educators expect from science instruction? The use of advertising in educational sources provides teachers, both today and in the early days of science instruction, a look at the new technologies and teaching methods of their current times. Periodic literature and textbooks of the late-nineteenth century provide evidence of the ideas and technologies to which science teachers of that time were exposed. This continues today. This paper uses a pictorial method of looking at the changing face of science education through the late-nineteenth and twentieth centuries as depicted through advertisements.

Environmental Science

PRELIMINARY ANALYSIS OF PERiphyton COMMUNITY STRUCTURE IN PREVIOUSLY IMPACTED AREA OF RAPPAHANNOCK RIVER BASIN. Michael L. Bass, Department of Environmental Science and Geology and Stephen B. Gough, Department of Biological Sciences, Mary Washington College, Fredericksburg, VA 22401. Studies of the periphyton communities structure are ideal environmental indicators when monitored over time. Periphyton growth and species composition reflect the impact of multiple stressors through time. In the Spring 1980 and Winter 1990 ruptures in Colonial Pipeline Company's refined oil products line spilled No. 2 fuel into Mine Run Creek in Orange Co., Virginia. Mine Run is a tributary of the Rapidan River that merges with the upper Rappahannock River a few miles west of Fredericksburg. Periphyton samples were taken using a bar-clamp sampler and analyzed by cell counting. Four sites coincident with previous samplings were selected. Previous studies indicated a low d of the periphyton community in the Rapidan River immediately below Mine Run. Although the diversity was found in this study to be higher, the lower d was still evident in the Rapidan immediately below Mine Run. This may follow the immediate disturbance theory and lack of uniform environment in this region of the river. Further study will attempt to clarify this.

EVALUATION OF A SCORING SYSTEM FOR TOOTH LESIONS IN MULE DEER (*Odocoileus hemionus*). Luz M. Borrero and Patrick F. Scanlon. Dept. of Fisheries and Wildlife, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061-0321. The purpose of the study was to evaluate the consistency in of a classification method to determine tooth lesions in mule deer (*Odocoileus hemionus*). The system used scored tooth lesions on a scale from 0 to 5, with the former having no lesions and the latter being severely affected. A group of 11 people, each with no previous experience, were trained to score tooth lesions and estimate age of the deer. The incisors of 14 jaws representing all possible scores were scored by the evaluators and their score were compared to the instructors score. On average, there was 71.3% consistency between the judges and the instructor. The method was used to standardize a technique to be used in future evaluations of tooth lesions in mule deer. [Supported by a grant from the U.S. Air Force and a Fulbright Grant.]

TEETH LESIONS IN MULE DEER (*ODOCOILEUS HEMIONUS*). Luz M. Borrero and Patrick F. Scanlon. Dept. of Fisheries and Wildlife, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061-0321. Incisors from 228 jaws collected from mule deer (*Odocoileus hemionus*) at the USAF Academy Colorado Springs, Colorado during the Fall/Winter 1993 legal hunting season. The tooth lesions were classified based on a method used by Shupe et al., 1963 (Am. J. Vet. Res. 24:964-979) to determine tooth lesions produced by fluoride in cattle. The scale used ranged from 0 (no lesions) to 5 (severely affected). In 193 deer jaws(84.6%) lesions were present on at least one of the incisors. Of the deer with lesions, 166 (86%) had at least one tooth with very slight effect (one to few white spots), 19 (9.8%) had a slight effect (generalized mottling), 5 (2.6 %) had a moderate effect (generalized mottling and wear), 2 (1.04%) had a marked effect (mottling and hypoplasia of the enamel), and 1 (0.52%) of the deer had severe effect (hypoplasia of the enamel and abnormal wear). Lesions that affect the enamel are produced during the period of formation of the tooth. The severity of the lesion depends on the cause and the length of exposure to the causative agent. Generally mottling and hypoplasia of the enamel are associated with fluorosis. Other causes of hypoplasia are malnutrition and trauma to the tooth. [Supported by a grant from the U.S. Air Force and a Fulbright Grant.]

MACRONUTRIENT POOLS IN ACCIDENTAL WETLANDS ON SURFACE MINED LANDS OF SOUTHWEST VIRGINIA. C. R. Bern, R. B. Atkinson, and J. Cairns Jr., Dept. of Biology, VA Tech, Blacksburg, VA 24061-0406.

Carbon, nitrogen, and phosphorus levels were measured in four compartments in twelve accidental wetlands at the Powell River Project in Wise County, VA. All of the accidental wetlands formed on mine benches created prior to the 1977 Surface Mine Control and Reclamation Act. The compartments studied included: live aboveground plant structures, plant litter, belowground plant structures, and soil. These compartments were analyzed for 71 0.25m² plots in two communities. The communities were divided by indicator status of dominant vegetation species and included obligate wetland and facultative wetland communities, dominated by *Typha latifolia* and *Scirpus cyperinus* respectively. Nitrogen concentrations were highest in soil and in roots (5.7 g/0.25m²), while maximum phosphorus content was found in litter (0.15 g/0.25m²). National Wetland Inventory estimates of wetland frequency in the two quadrangles studied, Flat Gap and Norton, Virginia, found 270 and 421 accidental wetlands, respectively. Analysis of the macronutrient levels measured indicate that accidental wetlands may serve as a significant sink for nitrogen and possibly phosphorus in the region.

USE OF HPLC TO DETERMINE PHYTOPLANKTON PIGMENTS IN ALGAL CULTURES AND FIELD SAMPLES. Jiangfeng Chen (*) & R. Christian Jones, Dept. of Biol., George Mason Univ. , Fairfax, Va. 22031. Major chlorophylls and carotenoids both in unicellular cultures and field samples of phytoplankton could be quickly separated, identified and quantitated by an pigment analytical method developed on high-performance liquid chromatography (HPLC). The usefulness of pigment chemotaxonomy in phytoplankton study was tested in lab cultures of many algal species isolated from the field and in a well studied tidal freshwater environment, Gunston Cove (Potomac River). By selecting taxon-specific pigments, the diverse phytoplankton community could be classified into different algal classes. A dominant genus of cyanobacteria, *Raphidiopsis*, was also positively identified. The concentrations of taxon-specific pigments also provided good indication of the relative abundance of the taxa they represent. Seasonal dynamics of phytoplankton community in the Cove studied by both pigment chemotaxonomic approach and conventional microscopic method demonstrated that pigment chemotaxonomic technique could be used as an useful alternative in environmental monitoring or ecological study of phytoplankton in nature waters.

STUDY OF FORESTED RIPARIAN BUFFER FOR REDUCTION OF NONPOINT SOURCE POLLUTION IN RAPPAHANNOCK RIVER BASIN. Kristen Eberly and Michael L. Bass, Department of Environmental Science and Geology, Mary Washington College, and Linda Porter, Friends of the Rappahannock, Fredericksburg, VA 22401. Riparian forest buffers are recognized as effective nutrient filters and erosion regulators to help improve water quality. The Rappahannock's major source of degradation is nonpoint source pollution which is tied to agricultural and urban run-off. Preliminary gathering of information about current forested riparian buffers in the counties surrounding the Rappahannock and Rapidan Rivers from the fall line up-river was begun. Studies of forested buffers from Maryland, Georgia and North Carolina have demonstrated significant reduction in nitrogen, phosphorous and sediments reaching waterways. Above the fall line of the Rappahannock, five of eleven monitoring stations have elevated nitrogen and phosphorous levels. Studies of aerial photographs show a good percentage of the shoreline is forested but many areas have thin or no forest buffer. Informative surveys and newsletters are being sent to agricultural landowners along the Rapidan and Rappahannock to encourage participation in local, state and federal programs that encourage riparian buffers.

A COMPARISON OF STRUCTURAL AND FUNCTIONAL MEASURES OF SOIL COMMUNITY DYNAMICS IN RECOVERING TERRESTRIAL SYSTEMS:

PRELIMINARY RESULTS. John R. Heckman and John Cairns, Jr. Department of Biology, Virginia Polytechnic Institute, Blacksburg, VA 24061.

A primary concern for ecological restoration lies in the ability to determine the point at which a system has satisfactorily recovered. Common recovery indices center around the development of a macro-community structure similar to the predisturbance condition. However, predisturbance condition is rarely known in detail and restored community structure is often dramatically divergent from the undisturbed community. A more defensible basis for measuring restoration efficacy is a comparison of ecological functions. Rate processes such as system CO₂ evolution and cellulose decomposition can serve as integrative measures of system activity that are less sensitive to structural differences. In this study, both approaches are used to compare the recovery process on land impacted by heavy machinery and topsoil removal. Sites have been reseeded with simple (6 species) grass/legume mixtures patterned after standard landfill closure mixes, diverse (15 species) tallgrass prairie mixtures and with no seeding at all. Half of the sites also received composted organic soil amendment treatments. Sets of structural (vegetational, microarthropod and microbial communities) and functional (CO₂ efflux, CH₄ uptake and decomposition rate) end-points are being observed within the different reclamation areas. Comparisons made between the different reclamation treatments and undisturbed reference areas will determine restoration progress and dependence of community recovery on initial reclamation techniques.

EFFECTS OF BIRD-RESISTANT SORGHUM ON THE NUTRITIONAL AND PHYSIOLOGICAL WELL-BEING OF NORTHERN BOBWHITES (*COLINUS VIRGINIANUS*)

Gerald A. Hish and Patrick F. Scanlon, Dept. of Fisheries and Wildlife, VPI & SU, Blacksburg, VA 24061-0321. The basis of bird resistance in sorghum (*Sorghum bicolor* L., Moench) is a higher concentration of condensed tannins. The effects of bird resistant sorghum (BRS) on several nutritionally related characteristics was measured in comparison to grain sorghum (GS) in a 2 x 2 factorial experiment with northern bobwhites (*Colinus virginianus*). Factors were ad libitum BRS vs GS and grit provided vs no grit provided. Mature, male bobwhites (N=48) were randomly assigned to one of the four treatments. Body mass and food and grit consumption were recorded weekly during a four-week trial and organ characteristics were measured after sacrifice. Body-mass in bobwhites eating GS diets remained consistent over time while those fed BRS decreased in body-mass during the trial. Food and grit consumption did not vary over time or between treatments. Cecal mass was not different between treatments though the mass of digesta contained in the ceca was higher for those with the BRS diet (P<0.05). The results indicate that weight loss due to BRS ingestion is not due to decreased food intake.
[Supported by a John Lee Pratt Animal Nutrition Fellowship.]

CHANGES IN THE ACID-BASE COMPOSITION OF THREE HEADWATER STREAMS IN SHENANDOAH NATIONAL PARK DURING PRECIPITATION EVENTS. Kenneth E. Hyer and Keith N. Eshleman*. Dept. of Environmental Sciences, Univ. of Virginia, Charlottesville, VA 22903. The changes in the acid-base composition of a stream during stormflow periods are important considerations when assessing a stream's sensitivity to acidification. Episodic acidification is the short-term loss of acid neutralizing capacity (ANC) in a stream associated with either precipitation or snowmelt events, and has been shown to have significant biological impacts. The objectives of this study were to (1) examine quantitatively the impact of storm events on the acid-base chemistry of streams in Shenandoah National Park (SNP) and (2) describe the sensitivity of streams on each of the different bedrock geologies in the Park to acid rain inputs. To this end, three forested mountain streams (Paine Run, Piney River, and Staunton River) in SNP were selected for this study based on their similar watershed size (11-13 km²) but different bedrock geology and baseflow ANC. During this study, stream samples were collected at eight hour intervals during baseflow periods and at two-hour intervals during storm events. All samples were analyzed for pH, ANC, and all major anions and cations. Over forty individual events have been sampled in this three-year field study. During events, significant changes in the acid-base chemistry of each stream have been observed. The pH and ANC decreased in all streams, with the ANC becoming negative several times in Paine Run. The greatest decreases in ANC were observed in Piney River where the baseflow ANC was highest. The smallest decreases in ANC were observed in Paine Run where the baseflow ANC was the lowest. Episodic acidification is occurring throughout SNP with low baseflow ANC streams appearing to be the most sensitive.

MACROINVERTEBRATE RICHNESS IN ACCIDENTAL WETLANDS ON SURFACE MINED LANDS OF SOUTHWEST VIRGINIA. David H. Jones, R. B. Atkinson, J. Cairns, Jr., Department of Biology, Virginia Tech, Blacksburg, VA 24061.

Surface mining operations completed prior to current regulations left novel features on the landscape. Specifically flat, compacted benches were created. In depressions on these benches accidental wetlands have formed. The macroinvertebrate community of nine accidental wetlands was inventoried during four sample periods between July 1993 and May 1994. During each period, three samples were taken from each site using a D-frame net. A total of 71 genera were identified, ranging from a maximum of 33 per site to 7 per site. These values are lower than natural wetlands, but comparable to wetlands on similar sites such as those associated with ball clay mining and relic gravel pits. Canonical Correspondence Analysis was used to identify relationships between the macroinvertebrate community and environmental parameters. The first axis was strongly correlated to hydrology and litter biomass. The second axis was related to water quality parameters. This information suggests design specifications for creating wetlands for ecological restoration. To encourage the development of the macroinvertebrate community wetlands should be positioned to avoid poor water quality and constructed deep enough to be permanently flooded.

SEASONAL PATTERNS IN SIZE AND ABUNDANCE OF *Eurytemora affinis* IN THE TIDAL FRESHWATER POTOMAC RIVER. R. C. Jones and A. Via-Norton, Department of Biology, George Mason University. Mesozooplankton were collected in Gunston Cove by horizontal tows with a 202 μ mesh plankton net. Zooplankton were counted until 200 animals had been collected. Total length of the first 10 adults and the first 40 copepodids was measured. Biweekly averages of *E. affinis* density from 8/10/93 through 7/20/94 show that for late summer and fall months adult density remains below 100 animals/m³. In late February the first of four moderately sized sequential peaks in adult abundance is observed. The largest of these peaks occurs in April, reaching just under 5000 individuals/m³. Adult density exceeds copepodid density in February, March and early April. Copepodid abundance in late summer, fall and winter remains below 1000 copepodids/m³. Between 3/31/94 and 5/4/94 copepodid density changes from a low of less than 100/m³ to a peak of nearly 15,000/m³. This peak rapidly declines to less than 2000 copepodids/m³ in late May and early June and is followed by a secondary peak of approximately 7000 copepodids/m³ in late June. The mean length of *E. affinis* adults and copepodid stage 3, 4, and 5 was found to decrease through late spring and summer. This decrease in size is possibly due to the differential effects of temperature on growth and maturation rates. It is likely that the maturation rate of *E. affinis* increases more rapidly with temperature than the growth rate resulting in smaller animals at maturity.

THE LOWER CHESAPEAKE BAY ZOOPLANKTON MONITORING PROGRAM: METHODOLOGY AND PROGRESS REPORT. George Mateja, R.S. Birdsong, H.G. Marshall, and R.W. Alden. Dept. Biological Sciences, Old Dominion Univ., Norfolk, Va. 23529-0266.

Zooplankton monitoring began in 1985 for the lower Chesapeake Bay and later expanded to include Elizabeth, James, York and Rappahannock River stations. Four distinct site groups were identified in relation to species composition (Bay entrance, eastern Bay, western and central Bay, and James River entrance). An abundance peak characterized July through October (that was associated with low flow periods), with a lesser pulse February-March. The annual mean concentration of the mesozooplankton was 16,600 m⁻³, ranging from 12,500 to 21,600 m⁻³. with a mean of 21 taxa per sample. In comparison, concentrations in the Elizabeth River were much lower. Results of a long term trend analysis (1985-1992) indicated positive trends in abundance and diversity occurred during spring, with negative abundance trends during November and December, and in diversity during July and August. Supported by the Va. Dept. Environmental Quality and EPA.

IMPACT OF PREDATION BY LARGEMOUTH BASS ON STOCKED STRIPED BASS IN SMITH MOUNTAIN LAKE, VIRGINIA. D.P. Michaelson*, and J.J. Ney. Dept. of Fisheries and Wildlife Sciences, VPI & SU, Blacksburg, VA 24061-0321.

Annual stockings of 300,000 fingerling striped bass, *Morone saxatilis*, into Smith Mountain Lake maintains a successful put-grow-take fishery. However, in this system only 20% of stocked fish survive their first year. Predation by adult largemouth bass, *Micropterus salmoides*, may be a significant cause of high mortality. We used night electrofishing in the summer of 1994 to examine largemouth bass gut contents and striped bass distribution patterns in two stocking coves. Striped bass made up less than 0.1% of largemouth bass diet whereas alewives, *Alosa pseudoharengus*, accounted for over 60%. We estimated by mark-recapture sampling that populations of largemouth bass averaged 700 fish per cove. Using bioenergetic expansion, total consumption by largemouth bass in each cove amounted to only about 30 striped bass. Predation on striped bass by largemouth bass is not a major component of initial mortality of stocked striped bass in Smith Mountain Lake and may be minimized by high availability of alewives as alternate prey.

LAND USE AND WATERSHED AREA AS DETERMINANTS OF FISH COMMUNITIES IN PRINCE WILLIAM COUNTY, VIRGINIA. Donald R. Morgan, Dept. of Biol., George Mason Univ., Fairfax Va. 22030., R.C. Jones, Dept. of Biol., George Mason Univ., Fairfax Va. 22030., & D.P. Kelso, Dept. of Biol., George Mason Univ., Fairfax Va. 22030. Three watersheds in Prince William County, Va., Neabsco, Powells and Quantico, are in various stages of development. An index of biological integrity (IBI) was used to evaluate the effects of watershed area and land use on fish communities within these watersheds. The IBI integrates twelve metrics of stream fish assemblages for assessing stream quality. Principal component analysis (PCA) on fish presence - absence data was also used as an index of community structure. Three rounds of sampling were conducted at 36 sites over a two year period. Sites in the three watersheds were divided into three sub-watershed size classes: Small (0.2-3 Km²), Medium (3-9 Km²), and Large (12-44 Km²). The results indicate major differences in IBI scores among sampling sites were related primarily to watershed area. Average IBI scores for the three sampling rounds revealed that sites in large sub-watersheds consistently received higher IBI scores than did sites located in small and medium sub-watersheds. The effects of surrounding land use were also demonstrated using average IBI scores. Sites in the small and medium sized sub-watersheds of Neabsco and Quantico received noticeably different average IBI scores based on metrics of species richness and composition. Little difference in average IBI was noted between sites located in large sub-watersheds. PCA showed similar results to those of the IBI, with noticeable differences in average PCA scores received by sites in the small to medium sub-watersheds of Neabsco and Quantico.

SEASONAL ABUNDANCE AND SPECIES COMPOSITION OF ROTIFERS IN LOWER CHESAPEAKE BAY AND ITS TRIBUTARIES. Gyung Soo Park, R.S. Birdsong, and H.G. Marshall. Dept. Biological Sciences, Old Dominion Univ. Norfolk, Va. 23529-0266

The abundance and seasonal succession of rotifers were examined in the lower Chesapeake Bay and four major tributaries (Rappahannock, York, James, and Elizabeth Rivers) over a 30 month period. Rotifers were most abundant in June (500/l), followed by July and August. The dominant species were Trichocerca marina, Keratella cochlearis, Polyarthra vulgaris, Brachionus angularis and Filinia longisetata in the freshwater stations during summer, and Synchaeta sp. in the mesohaline and polyhaline stations during winter. There was a significant inverse correlation ($r=0.9$, $P<0.01$) between the abundance of rotifers and salinity. The number of species and species diversity (H') also decreased with increased salinity. Supported in part by the Virginia Dept. Environmental Quality and EPA.

THE BIOACCUMULATION OF HEAVY METALS BY *PHRAGMITES AUSTRALIS*

Michael B. Price and Barbara Shipes, Dept. of Biology, and Wing Leung, Dept. of Chemistry, Hampton University , Hampton, VA 23668. A plant bioassay has been initiated for heavy metal accumulation by the halophyte *Phragmites australis* growing at the Craney Island Dredge Disposal Facility in Portsmouth, Virginia. The study analyzes heavy metal uptake and compartmentalization within *P. australis*, and compares metal uptake amounts in wetland and upland sediments.

FACTORS INFLUENCING BIOMASS PRODUCTION IN ACCIDENTAL WETLANDS ON SURFACE MINED LANDS OF SOUTHWEST VIRGINIA. C. Matthew Rosenquist, Robert B. Atkinson, and J. Cairns Jr., Dept. Biology, VA Tech, Blacksburg VA 24061.

Primary productivity in accidental wetlands is important for hydric soil development and several ecosystem services, e.g., sediment trapping and wildlife habitat. This study compared sediment depth, hydrology, and soil nutrient concentrations with peak aboveground biomass at 12 accidentally formed wetlands at the Powell River Project in Wise County, VA. Biomass estimates and soil samples were taken at 71 0.25-m² plots, which were differentiated into two dominant community types. Mean biomass estimates were similar in 1993 (405 g/m²) and in 1994 (485 g/m²). Species biomass and environmental parameters for each plot were analyzed using canonical correspondence analysis. Results of this study revealed that (1) the accidental wetlands showed biomass production within the range for similar, naturally-occurring wetland communities, (2) sediment depth and water depth were most strongly associated with species-wise biomass estimates, followed by P and N soil concentrations, and (3) biomass production demonstrated resilience to drought. Certain accidental wetlands may provide a model for wetland construction, which would improve reclamation practices.

SIMULATION OF A SHALLOW ESTUARINE ENVIRONMENT WITH A NOVEL MICROCOSSM SYSTEM. Thomas Small and Stephen Gough, Dept. of Biological Sciences, Mary Washington Col., Fredericksburg, VA 22401. For the past fifteen years, the Marine Systems Laboratory (MSL) of the Smithsonian Institute has designed and implemented many unique microcosms and mesocosms which are long-lived and virtually self-sufficient. These systems utilize turf algae to remove excess animal waste. Unlike standard methods of water filtration, the algae more readily replicates natural nutrient cycling. To date, research has focused on large synthetic environments (e.g., a 65,000 liter Delaware Bay ecosystem and a 2,000,000 liter Great Barrier Reef ecosystem). The potential for using encapsulated ecosystems for fundamental environmental research and ecological damage assessment is great, although the concept has been fraught with high construction costs (\$100,000 or more) and space constraints. To better exploit these systems in environmental research, we have designed and constructed a small scale, inexpensive (\$5,000) 2,000 liter microcosm based on the MSL algal turf scrubber design. This system emulates a shallow mesohaline environment located on the York River in Virginia. We are assessing the biological and chemical stability and are comparing the results with (a) organisms maintained under traditional (non-microcosm) conditions and (b) biotic and abiotic components of the York River site. At present, the microcosm has functioned successfully as an independent ecosystem and appears to have similarities with the natural environment.

A COMPARISON OF PERIPHYTON ON NATURAL AND ARTIFICIAL SUBSTRATES. Andrew G. Sales, Dept. of Biol., Mary Washington Col., Fredericksburg, VA 22401, & S. B. Cough Dept. of Biol., Mary Washington Col., Fredericksburg, VA 22401. Periphyton communities have been used as indicators of ecosystem health because they represent the net effect of physical and chemical factors on aquatic organisms. To study the diatom community, researchers can either sample from naturally occurring surfaces or establish their own artificial substrates. Natural surfaces tend to portray natural assemblages but may be less statistically precise. Conversely, artificial substrates may be more statistically valid, but can fail to accurately represent the true community. In this investigation, the diatom communities on natural rock, clay tile, and glass slide substrates were compared. The genera on the glass slides were more evenly distributed, whereas the natural rock tended to be dominated by *Melosira*. Additionally, both artificial surfaces did not contain the large quantity of silt particles found on the natural rock. Moreover, a technique was developed which allowed for rapid preparation of slides and avoided the need for cumbersome nitric acid treatment of the samples.

GROWTH, DIET, AND DISTRIBUTION OF AGE-0 STRIPED BASS (*Morone saxatilis*) IN SMITH MOUNTAIN LAKE, VIRGINIA. Trent M. Sutton* and John J. Ney. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061.

First-year survival of stocked fingerling striped bass (*Morone saxatilis*) in Smith Mountain Lake, Virginia, is inversely density-dependent; trophically-induced starvation is a probable cause. Age-0 striped bass were collected weekly from mid-June through mid-September 1994 by night electrofishing to describe temporal patterns of growth, diet composition, and distribution during the first summer of life. Over this period, age-0 striped bass grew from 42 to 99-mm median total length (TL) and a bimodal size distribution developed by mid-August with modes at 76 and 115-mm TL. The divergence in size distribution appeared to be due to differences in diet composition and dispersion from the stocking site. Large age-0 striped bass shifted from a diet consisting of zooplankton and benthic aquatic insects to one dominated by age-0 fish beginning in mid-July as they dispersed from the stocking site. In contrast, small age-0 striped bass remained within the general stocking area and fed predominantly on zooplankton and benthic aquatic insects. As a result, small age-0 striped bass may suffer disproportionate overwinter starvation due to low accumulation of energy reserves.

PATTERNS IN OCCURRENCES OF DEER-VEHICLE COLLISIONS. J. R. Swift, P. F. Scanlon, M. G. Babler, and R. W. Rexroad, Dept. of Fisheries and Wildlife, VPI & SU, Blacksburg, VA 24061-0321. Patterns of collisions involving white-tailed deer (*Odocoileus virginianus*) in a Virginia city were examined before and after a population control method was initiated. Deer-vehicle collisions occurred most frequently in November, and the interval of October through December. Collisions were more likely to occur in dark conditions with lesser numbers during periods of dawn and dusk. A substantial decline in deer-collision frequency occurred after the population control program was undertaken; however, the same temporal patterns of collisions was noted. Comparable temporal patterns in vehicle collisions with mule deer (*O. hemionus*) were noted at a military base in Colorado, i.e. collisions peaked in November, occurred most frequently during the months October through December, and under night-time conditions. Population control measures were associated with fewer accidents. Results indicate that driver educational efforts can be designed and focused to concentrate on the times of highest accident probability.

Geography

MODELING NEOTROPICAL MIGRATORY BIRD HABITAT ON THE GEORGE WASHINGTON & JEFFERSON NATIONAL FORESTS. Gregory K. Dillon,* Dept. of Geology and Geography, James Madison Univ., Harrisonburg, Va. 22807. The purpose of this project has been to develop a model that will reliably show areas of potential neotropical migratory bird habitat on the George Washington and Jefferson National Forests (GW&J NFs). Such a model would provide a useful tool to Forest Service officials in making forest management decisions. The prototype model was developed by the Deerfield Ranger District. A matrix was first compiled showing the optimal breeding habitats for ninety-one bird species. The criteria used in determining optimal habitat were forest type and successional stage, based on existing work on relationships of bird species to vegetation types (Hamel, 1992). Using this matrix and the GW&J NFs' Continued Inventory of Stand Condition (CISC) GIS database, an Arc Macro Language (AML) script was created within Arc/Info to model the habitat areas. Using the AML to query the database for the forest types and stand ages required by a particular species, the GIS is able to select and graphically display all areas meeting those requirements. The resultant product is a map showing areas of optimal habitat for each neotropical migratory bird species.

LAND USE/LAND COVER ANALYSIS OF AN AREA BEHIND THE VALLEY MALL, HARRISONBURG, VIRGINIA, 1966-1992. Jennifer A. Ware,* Dept. of Geology and Geography, James Madison Univ., Harrisonburg, Va. 22807. Urban encroachment onto rural land is a major feature of land use change. Cropland is twice as likely to be urbanized than non-cropland. Other land use problems include degradation of the environment, such as erosion and loss of wildlife habitat, and conflicts over control of land. Studies based on aerial photography were used to compile a land use/land cover analysis of an area behind the Valley Mall in Harrisonburg, Virginia. Their data was normalized to reduce discrepancies, particularly in the delineation of the area's boundary. An additional year of data was extracted from a land use/land cover map based on Landsat TM imagery dated August 24, 1992. The map was created using supervised training, maximum likelihood classification, and thresholding. The data was then graphed to show change over time of four land uses: urban, agricultural, forested, and barren. Urban and barren land use increased, agricultural use decreased, and forested use stayed about the same. This pattern was the expected result.

Geology

MAGNETIC AND GRAVITY SURVEYS OF AMELIA COUNTY: PRELIMINARY RESULTS. Earl H. Budke, Jr. Dept. of Geol., Va. State Univ. Petersburg, VA 23806. Amelia County is noted for its rich geology; particularly over seventy old mines and prospects-like the Morefield. Using a proton magnetometer and taking readings every fifty feet, over one hundred and fifty miles of road were covered in Amelia County and part of northern Nottoway County. The magnetometer data revealed the presence of a number of faults and dikes: of particular interest were five "graven-like" objects. A detailed gravity survey was run over two of them and again indicates the presence of a graben-like object. The gravity map of the Richmond Basin indicates a gravity low in the middle of the Amelia Courthouse quadrangle map on either side of Five Forks Road. A detailed gravity survey was run along approximately two miles of this road to determine the reality of the indicated gravity low. (Unfunded research.)

A MAGNETIC SURVEY OF A PORTION OF THE MOUNT HOREB KIMBERLITE.

Andrew W. McThenia III, Dept. of Environmental Sciences, Univ. of Va., Charlottesville, Va. 22903. Preston Hawkins, North American Exploration, Charlottesville, Va. 22903. Several traverses were made with a proton precession magnetometer (GeoMetrics model G-856A) across two of the three known intrusions of kimberlite near the Mt. Horeb Church in southwestern Rockbridge County. A grid was established across the northernmost mapped body and the magnetic data was collected and contoured. This survey failed to reveal any significant variation between the magnetic field of the kimberlite and that of the surrounding Ordovician carbonate rocks.

Two parallel traverses approximately 200 feet apart were made across the most accessible portion of the largest southernmost exposure of kimberlite. Measurements of the total magnetic field were collected every twenty feet along these two lines. A significant (> 200 gammas) magnetic anomaly less than 100 feet wide was detected, but no appreciable variation in total field was observed across traversed host rock contacts. The anomaly suggests that the intrusion is inhomogeneous with respect to ilmenite and magnetite content and perhaps represents a distinct phase of intrusion.

USE OF THE DIRECT SHEAR DEVICE AS AN AID TO THE STUDY OF MOHR'S CIRCLE. Michael T. Coffey*, W. Cullen Sherwood, Dept. of Geology and Geography, James Madison Univ., Harrisonburg, Va. 22807. Shear strength data derived from Mohr's Circles are used in a wide range of geotechnical applications. For soils, the two most commonly used methods for developing the Mohr's envelope are the triaxial method and the direct shear method. The direct shear device is the least expensive and simplest of the two which makes it an ideal tool for educational use. Briefly, the method involves compacting the soil under test in a split chamber and moving one half of the chamber, causing the soil to shear. The shear stress (τ) required is measured by proving rings and dial. By varying the weight perpendicular to the shear plane (σ_n), τ can be determined for a range of σ_n values. The values for σ_n and τ can then be plotted to produce the Mohr's envelope. The envelope allows the determination of maximum shear strength (σ_1), shear stress in the shear plane (τ), stress perpendicular to the shear plane (σ_n), angle of internal friction (ϕ), and cohesion, at any confining stress (σ_3).

NARROWS LANDSLIDE, GILES COUNTY, VIRGINIA. Gary K. Rogers, P.E., Ph.D., W. Grigg Mullen, Jr., P.E., Ph.D. Dept. of Civil and Environmental Engineering, Virginia Military Institute, Lexington, VA, 24450-0304. [ROGERSGK%CIVILENGR%VMI@IST.VMI.EDU] A historical, geological, and geotechnical overview of a famous landslide, nicknamed "Galloping Gertie", that has had deformations documented since 1916. Current evaluation techniques (e.g. geotechnical sampling/testing and two-dimensional limit-equilibrium analyses) and remediation plans are discussed as well as long-term monitoring options for this complex and difficult site. (Supported by the Virginia Department of Transportation via the Virginia Military Institute Research Laboratories, Inc., VMIRL).

TEST VARIABILITY IN THE PIPETTE METHOD OF TEXTURAL ANALYSIS FOR SOILS. Emily M. Newman*, W. Cullen Sherwood, Dept. of Geology and Geography, James Madison Univ., Harrisonburg, Va. 22807. The variability of the pipette textural analysis method for soils was examined by analyzing the variance for the sand, silt, and clay fractions of three common Virginia soils. The soils selected for the test were a clayey residuum over Edinburg Limestone; a sandy alluvium; and mica-rich residuum over schist and gneiss. The number of tests required to assume whether the test results fell within a 5% tolerance interval of that specified, at 95% confidence were computed for each size fraction for each soil. The experiment included ten pipette analyses for each of the three soils. Variance was found to range from a low of 2.12% for the sand fraction of the Millrock to a high of 56.08% for the clay fraction of the Millrock. It was concluded that variance is generally inversely proportional to the mean weight percent of the fraction, and in cases where fraction size is low and variance is high, more samples must be tested in order to maintain a + or - 5% tolerance and low risk. For example, required tests ranged from a low of 1 for the Millrock sand fraction to a high of 503 for the Millrock clay fraction. These results appear to be related to the very small sample sizes involved in the pipette method. Even small weighing and other errors are magnified significantly, increasing test variability.

THE OXIDATION STATE OF SPINEL XENOCRYSTS FROM MOLE HILL, ROCKINGHAM COUNTY, VA. Kelly K. Greaser[†] and F. Ó. Dudás*, Dept. of Geology, and Desmond C. Cook, Dept. of Physics, Old Dominion Univ., Norfolk, VA 23529. The olivine basalt of Mole Hill contains mantle xenocrysts of spinel, pyroxene and olivine. The 48±1 Ma (Wampler, 1975), plug-shaped intrusion consists of nepheline-normative, uniformly fine-grained basalt that is compositionally similar to other Eocene igneous rocks in western Virginia. Intrusion in this tectonically stable region might be due to decompression during reactivation of deep fractures. The basalt contains ≤ 8 vol. % xenocrysts ranging from 0.5 to 4 cm in size. Most xenocrysts are monomineralic; clinopyroxene is predominant, with subordinate olivine and spinel. Orthopyroxene may be present, suggesting a spinel lherzolitic source. Unlike phenocrysts, the xenocrysts have distinct reaction rims. Clinopyroxene is rimmed by another generation of pyroxene; spinel has rims of magnetite + plagioclase. Because the spinel to plagioclase reaction occurs at $P \leq 10$ kbar, the inferred source of the xenocrysts lies at depths exceeding 30 km, in the lower crust or mantle. Electron microprobe analyses of the xenocrysts show compositions that are similar to those of mantle-derived minerals in other xenolith suites. Mössbauer spectroscopy of the spinels allows precise determination of their $\text{Fe}^{2+}/\text{Fe}^{3+}$, and, combined with the microprobe data, leads to estimates of temperature from the olivine - spinel geothermometer, and oxidation state of the mantle source. [†]Supported by an ODU undergraduate research award to KKG.

COMPUTER SIMULATION OF EVOLUTION OF FABRICS IN IGNEOUS ROCKS: PLANS FOR A NEW RESEARCH TOOL. Trudy G. Krohn*, Michael J. Bonder*, Michael C. Leopold*, Roddy V. Amenta, Dept. of Geology and Geography, James Madison Univ., Harrisonburg, Va. 22807. Experimental methods in petrology coupled with thermodynamics have yielded information on the stability fields of rock forming minerals. However, current methods are not able to reproduce the coarse grained igneous and metamorphic rocks due to the slow reaction rates involved. Computer simulation of geologic crystallization processes may be the only way to study the evolution of these rocks and their fabrics. Earlier efforts on this project dealt with the growth of circles and then of polygons as representations of crystals, and on resolving the competition for growth space among growing moving crystals in a melt. Our present efforts deal with methods for changing the shapes of crystals as they grow so that they exhibit more natural looking boundaries, and on adding unit cell-like elements to each crystal. These elements provide a means for controlling the location and composition of chemical species in a crystal.

Materials Science

INVESTIGATION OF UNIDIRECTIONAL COMPOSITE STRENGTH USING A SINGLE TOW COMPOSITE TEST. Paul E. Cantonwine, and Haydn N. G. Wadley, Dept. of Materials Science and Engineering, University of Virginia, Charlottesville, VA 22903. Composite processing has traditionally involved surrounding a coated single fiber with either a metal or ceramic matrix. For the monofilaments like SCS-6 (SiC) which have a diameter of 140 μm , traditional processing works well. However, tow based fibers like Nextel 610 (Al_2O_3) which have a 10 μm diameter and come in bundles of 400 to 1000 filaments are inherently more difficult to process traditionally. An alternative process for a tow based fiber is to make the tow like a monofilament by binding the filaments together with a thermodynamically compatible material and then surrounding this "hybrid" monofilament with the desired matrix material. The work presented at VAS will pertain to how fiber strength is affected during this new composite process. Specifically showing how damage occurs and can be avoided.

MICROSTRUCTURAL PROPERTIES OF MECHANICALLY PROCESSED HIGH NITROGEN IRON ALLOY POWDERS. Desmond C. Cook and James C. Rawers*, Department of Physics, Old Dominion University, Norfolk, VA 23529. *U.S. Bureau of Mines, Albany Research Center, Oregon 97321.

Iron powder has been mechanically processed in an ATTRITOR ball mill in nitrogen gas for up to 250 hours and investigated by Mössbauer spectroscopy, X-ray diffraction and TEM. We have separated microstructural changes due to mechanical processing from those due to nitrogen infusement by also processing the powders in argon gas. Processing in argon resulted in a continuous decrease in grain size and after 150 hours produced 5-10 μm particles with 70 nm grains. When processed in nitrogen, the nitrogen concentration in the iron powder increased linearly with processing time. After 50 hours, the nitrogen concentration was 0.5 wt%. With continued processing, a highly stable subnanocrystalline bct-Fe microstructure formed in a nanocrystalline bcc-Fe matrix. For the iron powder we observed an increase in internal strain and interstitial nitrogen concentration which resulted in a supersaturated, highly strained bcc-Fe structure. The locally induced strain suddenly decreased through continual processing to form the bct-Fe microstructure as a result of the redistribution of some highly mobile nitrogen atoms.

ANALYSIS OF CRACK PROPAGATION IN ADHESIVE LAYERS. Victor Giurgiutiu, Dave Dillard, Jeff Graffeo, Dept. of Eng. Science and Mech., Virginia Tech, VA 24061-0219. Cracks in adhesive layers have been experimentally observed to propagate both interfacially as well as cohesively in straight or wavy paths. A common approach to the analysis of such cracks is to study a layer of brittle adhesive bounded between 2 elastic half-planes representing the substrate. Hence, a 2-material 3-region elasticity problem is set up and has to be solved. A theoretical model based on work done by Fleck, Hutchinson, and Suo (1991) is used to predict the stress distribution around the crack tip. Two complex potential problems were set up for the 3-region, 2 material model: (a) a distribution of edge dislocations to simulate the crack and its near field; and (b) a crack-free problem to simulate the external loads applied in the far field. Superposition of the two problems was followed by stress and displacements match at the boundaries. Imposing the traction-free boundary conditions over the entire crack length yields an integral equation formulation. To find the numerical solution, the distribution of dislocations is represented by a series of Chebyshev polynomials. Next, the integral equation is collocated on Gauss-Legendre points. The resulting linear system of equations yields the Chebyshev series coefficients and, hence, the distribution of dislocations. Several advanced numerical techniques were utilized to perform the computation on a standard PC with controlled accuracy. High order Gauss quadrature and Romberg exact integration were comparatively used to evaluate convergence of the integrals. "Numerical freeze" and interpolated functions were used to reduce computational time. The Fast Fourier Transform was employed to calculate sine and cosine Fourier integrals. (Supported by the Virginia Tech NSF-STC High Performance Polymeric Adhesives and Composites, contract DMR 9120004)

IDENTIFICATION OF THE FE-ZN INTERMETALLIC PHASES IN COMMERCIAL GALVANNEAL STEEL". Richard G. Grant and Desmond C. Cook, Department of Physics, Old Dominion University, Norfolk, VA 23529.

Commercially produced galvanneal, (Zn-Fe alloy), coatings on steel sheet have been studied using transmission and scattering Mössbauer spectroscopy. In scattering geometry spectra were recorded using conversion electron, (CEMS), X-rays, (XMS), and re-emitted γ -rays, (GMS). The results show that different amounts of four iron-zinc phases are present depending on the production conditions of the coating. The different phases are also distinctly layered with the high iron concentration Gamma phase forming as a very thin layer at the steel-coating interface. The Gamma-1, Delta and Zeta phases have also been identified as layered phases with the Delta phase being the most abundant. Many coatings often form without the zinc rich Zeta phase being present. Different numbers of iron sites are present in each phase, in agreement with our recent studies of laboratory produced high purity iron-zinc intermetallics. The layering characteristics of the phases are compared with metallographic cross section analysis.

*Supported in part by International Lead Zinc Research Organization, Inc, grant ZM-403 and Virginia's Center for Innovative Technology, grant MAT 93-018.

DIRECTED VAPOR DEPOSITION OF ELECTRON BEAM EVAPORANT FOR STRUCTURAL AND ELECTRONIC MATERIALS PRODUCTION. James F. Groves and Haydn N. G. Wadley*. Materials Science and Engineering Dept., Univ. of Virginia, Charlottesville, VA 22903. A unique system for producing materials has been invented which makes possible high rate, efficient, and inexpensive creation of thick and thin films for various applications. Using a modified electron beam gun, the directed vapor deposition (DVD) system possesses the same rapid, high temperature heating and evaporation capabilities of traditional e-beam systems but is capable of operating in low vacuum (0.1 - 5 Torr) rather than the high vacuum (10^{-5} - 10^{-7} Torr) of traditional e-beam systems. This environment shortens processing times and eliminates the need for expensive pieces of high vacuum equipment. Directed vapor deposition of e-beam evaporant facilitates efficient materials creation by allowing capture of evaporated materials in a helium gas stream which directs the concentrated vapor onto any desired substrate, (e.g., flat, fibrous, or multifaceted). This focussing of the vapor stream makes DVD more efficient than traditional e-beam systems where vapor streams follow a $\cos^n\theta$ distribution ($n = 2, 3, 4$, or higher) and thus fail to deposit large amounts of valuable source material on the desired substrate. The higher deposition efficiency of the DVD system may decrease processing time and final product costs enough to make it the most cost competitive method for the production of numerous structural and electronic materials. A wide variety of materials have been successfully evaporated and deposited including copper, titanium, zirconium, silicon, and holmia. Compound production (e.g., zirconia) has been achieved by injecting reactive gases into the gas stream after metal vapor entrainment. Results show that the deposition rate and microstructural quality of the deposited films is directly dependent upon processing conditions. The most important processing conditions for controlling deposition rate and microstructural quality are 1) the velocity of the helium gas flow as it enters the processing chamber, 2) the pressure in the processing chamber, and 3) the temperature of the substrate.

DIELECTRIC PROPERTIES OF TAPE CASTING SLURRIES. Derek D. Hass, and Haydn N. G. Wadley, Dept. of Materials Science and Engineering, University of Virginia, Charlottesville, VA 22903. Advanced ceramic materials offer many advantageous properties for high performance structural applications such as low density, excellent high temperature strength, and high stiffness. Unfortunately the low toughness of these materials limits their use in aerospace applications where their properties offer the greatest potential. Ceramic matrix composites, in which continuous fibers are imbedded in a ceramic matrix can markedly improve the toughness of these materials by impeding crack propagation. Economical production of these materials requires a low cost processing approach able to produce the consistently high properties needed. Tape casting is an approach currently being investigated that satisfies these requirements. It involves a multicomponent slurry containing ceramic powder which is infiltrated into a woven fabric of continuous fibers. After heating to remove organic constituents a composite is produced by sintering a laminate of ceramic tapes. Compositional control of these slurries are dependent on slurry composition. An investigation of the effect of compositional changes on the dielectric properties of these slurries is being investigated to determine the possibility of using dielectric measurements for the on-line sensing of compositional changes during composite processing.

MÖSSBAUER AND X-RAY STUDY OF HIGH NITROGEN IRON ALLOYS PRODUCED BY HOT-ISOSTATIC-PRESSURE DIFFUSION. Tae H. Kim, Desmond C. Cook and James C. Rawers*, Department of Physics, Old Dominion University, Norfolk, VA 23529. *U.S. Bureau of Mines, Albany Research Center, Oregon 97321.

Investigation of the microstructural characteristics of powders of high nitrogen iron and iron-aluminum, produced by Hot-Isostatic-Pressure diffusion of nitrogen has been made using Mössbauer spectroscopy and X-ray diffraction. Nitrogen diffusion of the powders was performed at 1000°C at pressures up to 150 MPa. Vacuum fusion analysis indicated that nitrogen concentrations up to 4 a% and 7.3 a% were obtained in the iron and iron-aluminum samples respectively. Mössbauer analysis showed that for the iron and iron-aluminum powders the nitride Fe₄N formed at nitrogen concentrations greater than 1 a% and 4 a% respectively. The data indicates that the interstitial nitrogen content in the powders is substantially greater than the normal solubility limit.

PREPARATION OF PATTERNED GaAs SUBSTRATES FOR OPTOELECTRONIC INTEGRATION BY SELECTIVE LIQUID PHASE EPITAXY. David J. Lawrence, Integrated Science and Technology Program, James Madison University, Harrisonburg, VA 22807. Optoelectronic integration requires the fabrication of optical and electronic devices on a common substrate. Moreover, control of device isolation and interconnection must be achieved. Some devices (e.g., light emitting diodes, laser diodes and photodiode detectors) are most easily fabricated on a highly conducting substrate, while for others (e.g., field effect transistors and photoconductive detectors) an insulating substrate is preferred. Selective liquid phase epitaxy (LPE) is used to prepare patterned substrates for optoelectronic integration. These substrates consist of highly conducting (n^+ or p^+) GaAs regions embedded in semi-insulating GaAs. The desired optical and electronic devices can then be fabricated in the appropriate regions and interconnected as required. The substrate preparation process includes silicon nitride masking, channel etching, LPE refill and planarization. The solubility behavior of GaAs in gallium is exploited to allow in situ etching and refill during the LPE step.

CHARACTERIZATION OF FUNDAMENTAL HYDROTALCITE COATINGS ON ALUMINUM. Lysle Montes, Glenn Stoner, CESE, Dept. of Materials Science, University of Virginia, Charlottesville VA. 22903 & Rudy Buchheit*, Sandia Nat. Lab., Albuquerque, NM. 87185. Corrosion accounts for 4 to 5% of the U.S. GNP, of that 10-20% is spent on organic coatings. New EPA regulations restrict substances classified as toxic, hazardous or carcinogenic which has greatly impacted the coatings industry. Focus has been placed on development of non-toxic coatings. Hydrotalcite (HT) is a recently developed coating which is capable of passing many standard industry tests. Although the performance of advanced HT coatings looks promising, very little is known about the fundamental structure/morphology of this unique protective barrier. The purpose of the current research is to investigate the role of aluminum ion concentration and fluoride ion in coating formation. (Supported by the National Science Foundation and DOE - Sandia National Labs)

TWO DIMENSIONAL RECONSTRUCTION OF INTERNAL VELOCITY DISTRIBUTIONS IN MATERIALS BY ULTRASOUND TOMOGRAPHY. Haydn N. G. Wadley, Giridhar M. Prabhakar, Dept. of Materials Science and Eng., Univ. of Va., Charlottesville, Va. 22903. Near net shape processing of metallic powders can produce internal density gradients in the product. The need for non-destructive evaluation of these density gradients is addressed by measuring ultrasonic times of flight along various paths across the samples. From this information, the internal slowness (i.e., reciprocal velocity) distributions may be reconstructed. The ultrasonic velocity of a material is a strong function of its relative density. Hence, the relative density field can be assessed. A non-contact system for the laser generation and detection of ultrasound developed in our laboratory has been used to characterize the internal slowness distributions of test samples. These samples are metallic blocks of regular geometry (cylindrical, cuboidal) with other metallic inclusions that simulate abrupt density gradients. Two projection geometries (fan and parallel beam) have been used. Algebraic Reconstruction Techniques (ART) have been implemented in the two dimensional reconstruction of the images from these projections. Acoustic ray tracing has been carried out assuming continuous and discrete refractive boundaries. Results compare well with the a priori knowledge of the velocity fields of the samples. (Supported by ARPA/NASA)

INVESTIGATION OF THE ATMOSPHERIC CORROSION PRODUCTS ON LOW CARBON MILD STEEL EXPOSED IN A MARINE ENVIRONMENT. Sei Jin Oh, D.C. Cook and A.C. Van Orden*, Department of Physics and Department of Mechanical Engineering*, Old Dominion University, Norfolk, VA 23529.

The atmospheric corrosion products formed on low carbon mild steel exposed in a marine environment in Mexico for up to 1 year, have been investigated using Mössbauer spectroscopy, X-ray diffraction, and Raman spectroscopy. The Mössbauer analysis was performed in scattering geometry with the original coupons, as well as in transmission geometry with the naturally flaked powder from the corrosion coating and with the scraped powder. The spectra were recorded at 300K and 77K in order to separately identify the iron oxide phases present through their different temperature dependent hyperfine parameters. α -FeOOH, β -FeOOH, γ -FeOOH and Fe_3O_4 were uniquely identified. The β -FeOOH and γ -FeOOH phases are very adherent and form as the largest fraction for small exposure times. We determined from the analysis that the β -FeOOH fraction increased with increasing Cl^- concentration. The X-ray diffraction data and Raman spectroscopy agree well with the phases and their fraction as determined by Mössbauer spectroscopy.

PROCESSING OF AMORPHOUS FeW REINFORCED METAL MATRIX COMPOSITES BY MECHANICAL ALLOYING. Michael T. Stawowy and Alex O. Aning, Materials Science and Engineering Dept., Virginia Tech, Blacksburg, VA, 24061. Metal matrix composites commonly have bonding and chemical instability problems at the matrix and reinforcement interface which can result in poor mechanical properties. The mechanical alloying (MA) process was used to produce an amorphous FeW alloy reinforcement powder. The reinforcement powder was then blended at various volume fractions with a crystalline Fe matrix again using MA. The resulting composite powders were compacted and compression tests were performed. It was concluded that the amorphous particles produced significant strengthening, however, the strengthening was offset by a weakening due to porosity.

CONTROL OF METAL MATRIX COMPOSITE MONOTAPE DENSIFICATION DUE TO ASPERITIES. R. Vancheeswaran¹, R. Gampala², H.N.G. Wadley³. Dept. of Mechanical Engineering¹, University of Virginia, Charlottesville, VA 22903, Concurrent Technologies Corp.², Johnstown, PA 15904, Dept. of Materials Science and Engineering³, University of Virginia. In previous studies, the contact blunting of metal/alloy powders and of spray deposited MMC monotape surface asperities due both to time independent and time dependent plastic deformation have been analyzed. These contact blunting models have also been implemented into the densification and damage models of the MMC monotape given by Elzey and Wadley. Vancheeswaran et al. have utilized these densification models in turn to (i) predict the optimal process parameters and (ii) to subsequently control the consolidation processing of MMC monotapes. Here, a model for the contact blunting of monotape surface asperities due to primary (or transient) creep is first formulated following Ogbonna et al. In this formulation, the problem is set-up to analyze the contact blunting behavior of a representative hemispherical asperity and express the resulting response of the solid by a simple, uniaxial effective flow rule relating the mean contact stress with the displacement and velocity of deformation (In earlier studies it was shown that the mean stress at contact is dependent only upon the displacement and the velocity of deformation). This formulation also enables combining the blunting models due to time independent and time dependent mechanisms into one "unified" model. This unified blunting problem is then numerically solved using ABAQUS finite element analysis code for two composite systems of interest to the aerospace industry (Ti-24Al-11Nb/SCS-6 and Ti-6Al-4V/SCS-6). It will also be shown that a substantial simplification of the consolidation control algorithm is achieved with a densification model derived from a unified contact blunting. The simplifications are realized both from improved computational efficiency and ease of implementation of models into the control algorithm.

PATH PLANNING THE MICROSTRUCTURE DURING CONSOLIDATION OF POROUS TITANIUM METAL MATRIX COMPOSITE MONOTAPES. R. Vancheeswaran¹, H.N.G. Wadley². Dept. of Mechanical Engineering¹, University of Virginia, Charlottesville, VA 22903, Dept. of Materials Science and Engineering², University of Virginia. The high temperature consolidation of fiber reinforced titanium matrix composites (TMC's) seeks to reduce the concentration of matrix pores (i.e. increase relative density), simultaneously minimizing fiber microbending/fracture, and the growth of reaction product layers at the fiber-matrix interface. These three goals have conflicting dependencies upon the consolidation process variables (temperature and pressure), and it has been difficult to identify process pathways by "trial and error" that lead to composites of acceptable quality (where the fiber damage and reaction layer thickness are kept below some bounds, while matrix porosity is eliminated). Here, generalized predictive control (GPC) concepts have been combined with dynamic consolidation models to investigate the design of "locally" optimal process cycles that minimize fiber damage, reaction product layer thickness, and the pore concentration. The approach is then used to path plan the input process schedules for a variety of TMC systems. It identifies feasible process pathways for highly "processable" TMC systems such as Ti-6Al-4V/SCS-6, and reveals the best path for less processable systems like Ti-24Al-11Nb/SCS-6 and Ti-6Al-4V/Sigma-1240, and can determine when no successful path exists.

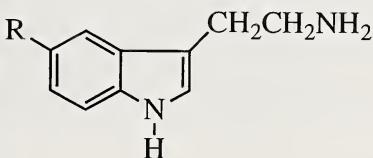
CORONA AND PLASMA PRETREATMENT OF CARBON FIBER/POLYMER MATRIX COMPOSITES. C. Espinoza, N. L. Lawrence and J. P. Wightman, Dept. of Chemistry, Va. Tech, Blacksburg, VA 24061. Adhesion is a multi-disciplinary science which involves in part an understanding of surface science and specifically, the interface between the substrate and the adhesive. The objective of this work was to document changes in composite surfaces following exposure to two types of electrical discharge. A commercial carbon fiber / epoxy matrix composite obtained from BASF was studied. Both a corona and plasma was used to pretreat the surfaces. Scanning electron microscopy showed minimal changes in surface topography due to pretreatment. On the other hand, the surface composition measured by x-ray photoelectron spectroscopy was altered significantly by corona and plasma exposure in air showing an increase in surface oxygen content. The surface energy of the pretreated composites was also higher than the untreated surfaces. Adhesion as measured by peel strengths increased with exposure to electrical discharges. [Research supported by NSF Science & Technology Center at Virginia Tech]

Medical Science

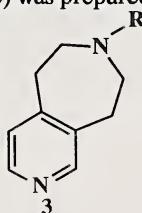
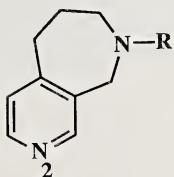
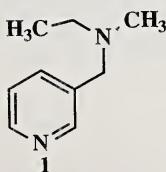
ALTERATIONS IN DIHYDROPYRIDINE-SENSITIVE CALCIUM CHANNELS IN THE BRAIN AND SPINAL CORD OF ACUTELY TREATED AND MORPHINE-TOLERANT MICE. Marissa A. Bernstein & Sandra P. Welch, Dept. of Pharmacology and Toxicology, Va. Commonwealth Univ., Richmond, Va. Opiate tolerance has been associated with changes in neuronal intracellular calcium levels. *In vivo* studies have indicated the involvement of dihydropyridine (DHP)-sensitive ("L-type") voltage-gated calcium channels in the morphine-tolerant state. In this study, we assessed how the morphine-tolerant state would affect the antinociception produced by intrathecal administration of two agents (Bay K 8644 and thapsigargin) that increase intracellular calcium. Morphine-tolerant mice displayed a 7-fold greater ED₅₀ for Bay K 8644 antinociception than placebo-treated animals; no difference was found in the dose-response curve for thapsigargin. To further explore the role of the L-type channel in morphine tolerance development, we performed radiolabeled nitrendipine binding studies in the spinal cord and brain regions associated with pain modulation from acutely treated, tolerant, and control mice. Binding site number and affinity were determined using Scatchard analysis for the following timepoints: 20 min and 60 min after s.c. injection of morphine or vehicle, as well as after 4 days of chronic administration, and after naloxone-precipitated withdrawal. Although some changes were observed in the affinity of nitrendipine for its receptor, a significant change in these measures was found only following naloxone withdrawal, which produced increases in B_{max} in both placebo- and morphine-treated mice.

(Supported by NIDA grants DA06031 and DA07027.)

NOVEL TRYPTAMINE DERIVATIVES AS 5-HT1D β SEROTONIN RECEPTOR LIGANDS. M. Bondarev*; S. Hong,* M. Dukat,* H. Law,* M. Teitler,* R.A. Glennon. Dept. of Med. Chem., MCV/VCU; Richmond, VA 23298. Although a few 5-HT1D agonists have been reported, none displays > 50 fold selectivity for 5-HT1D versus 5-HT1A receptors. In the course of our work with 5-HT1D and 5-HT1A receptors we suggested that both have regions of bulk tolerance associated with the aromatic portion of 5-HT. Due to low TM sequence homology (ca 50%) between the two receptors, we should be able to exploit structural differences in these regions. Accordingly, we examined a series of 5-alkoxytryptamine derivatives and identified several that bind with high affinity and up to 400-fold selectivity. For example, NOT (where R = $\text{CH}_3(\text{CH}_2)_8-$) binds at 5-HT1D β sites ($K_i = 1 \text{ nM}$) with 300-fold selectively. These types of compounds represent the most 5-HT1D selective agents reported to date.



CONFORMATIONALLY-RESTRICTED AMINOMETHYL PYRIDINE DERIVATIVES AS NOVEL NICOTINE RECEPTOR LIGANDS. Y.X. Cheng*, W. Fiedler,* M. Dukat,* I. Damaj,* B. Martin,* R.A. Glennon. Dept. Med. Chem., MCV/VCU, Richmond, VA 23298. The aminomethylpyridine **1** ($K_i = 28 \text{ nM}$) represents a novel nicotine receptor ligand. Due to its rotational flexibility, we prepared the more conformationally restricted **2**. Interestingly **2** (R = H or Me) binds with significantly reduced affinity ($K_i = > 1,000$ and 780 nM, respectively). Although **3** contains an additional methylene between the aromatic ring and terminal amine, it possesses molecular dimensions similar to nicotine. Compound **3** (R = H, Me) was prepared and examined for nicotinic activity.

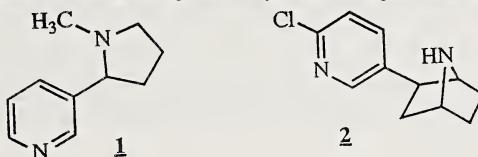


THE DEVELOPMENT OF TOLERANCE IN MICE TO EPIBATIDINE DIFFERS FROM THAT OF NICOTINE. Kimberly R. Creasy, M.I. Damaj, B.R. Martin, Dept. of Pharmacology and Toxicology, Medical College of Virginia, Virginia Commonwealth University, Richmond, VA 23298-0613. Epibatidine, an alkaloid originally isolated from frog skin, is a potent nicotinic agonist that produces analgesia in different animal tests. Tolerance to nicotine's behavioral and physiological effects after acute and chronic administration has been established and previously reported. In this study, we evaluated the tolerance profile of epibatidine optical isomers and compared it to that of nicotine. Male ICR mice were used and analgesia was measured by the tail flick test. Contrary to nicotine, mice treated with subcutaneous administration of epibatidine at different doses did not display significant tolerance after acute administration in the tail flick test. After chronic administration of epibatidine (12 µg/kg, sc, bid, 10 days), a significant shift of the dose response curve was observed in the (-) isomer only, however this shift was only slight (two fold compared to a five fold shift in nicotine). Cross tolerance studies involving both isomers and nicotine revealed only a slight, desensitized response to the (-) isomer after previous exposure to nicotine. Studies to provide explanations for the differential mechanisms of tolerance development in epibatidine and nicotine are needed. (Supported by the National Institute on Drug Abuse DA-05274.)

BENZO[a]PYRENE-INDUCED IMMUNOSUPPRESSION *IN VITRO* MAY BE ATTENUATED BY CO-CULTURE WITH INHIBITORS OF THE PEROXYL RADICAL PATHWAY. Clifford L. Deal, III,¹ and Kimber L. White, Jr.,^{1,2} Depts. of Pharmacology and Toxicology,¹ and Biomedical Engineering,² Med. Col. of Va./VCU, Richmond, Va. 23298. Metabolism of benzo[a]pyrene, B(a)P, an ubiquitous environmental contaminant, by splenic macrophages has been shown to be mediated by P-450 and peroxy radical pathways. Previous work has also demonstrated that the suppression of the *in vitro* T-dependent antibody forming cell (AFC) response following exposure to B(a)P or B(a)P 7,8 diol is able to be attenuated by co-incubation with the P-450 enzyme inhibitor, alpha-naphthoflavone(ANF). The objective of these studies was to determine if the *in vitro* immunosuppression was attenuated by the dual cyclooxygenase and lipoxygenase enzyme inhibitors, eicosatetraynoic acid (ETYA) or BW 755C. Immunosuppression was evaluated using the *in vitro* T-dependent AFC assay to sheep erythrocytes (sRBC). Naive splenocytes from B6C3F1 female mice were incubated with vehicle or B(a)P (0.1 nM-10µM) ± ETYA (10 nM -10µM) or BW 755C (50 nM -50 µM) for 30 minutes or five days, then placed in culture with sRBC. AFC were enumerated on day five. As a result of inherent immunosuppression with five day exposure to drugs, an alternate experimental approach was undertaken, limiting exposure of B(a)P and drugs to the first 30 minutes, followed by washing and resuspending the splenocytes in fresh media. No effect levels for the 30 minute exposure to ETYA and BW 755C were 10µM and 500µM, respectively. No reversal of B(a)P induced immunosuppression was observed following 30 minute co-incubation with 10µM ETYA. However, the B(a)P-induced decrease in the AFC response was attenuated at all dose levels by the co-incubation with 50µM BW 755C for 30 minutes. Our data demonstrate that inhibition of the peroxy radical pathway may attenuate B(a)P-induced immunosuppression, probably through the inhibition of B(a)P activation to its immunosuppressive metabolites. Supported in part by NIEHS contract ESO 05288.

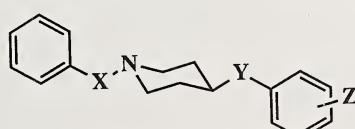
DIFFERENTIAL CONTRIBUTION OF THE OXYGEN ATOMS TO THE BINDING OF PROPRANOLOL ANALOGS AT 5-HT1D β AND MUTANT 5-HT1D β SEROTONIN RECEPTORS. M. Dukat,* A.M. Ismaiel,* R.B. Westkaemper,* E. Parker,* R.A. Glennon. Dept. Med. Chem., MCV/VCU, Richmond, VA 23298. 5-HT1B serotonin receptors represent rodent autoreceptors, whereas in humans, these receptors are termed 5-HT1D β receptors. These receptors represent species homologs and agents that bind at one population generally bind to the other. Propranolol is an agent that binds at 5-HT1B receptors but represents an anomaly in that it binds with low affinity at 5-HT1D β receptors. Because a key structural difference between these two receptors is the presence of an asparagine in TM7 of 5-HT1B versus a threonine (T355) at the corresponding position of 5-HT1D receptors, we synthesized and examined the binding a series of propranolol analogs at 5-HT1D β receptors and at mutant 5-HT1D β receptors where T355 had been replaced by asparagine. We conclude that propranolol displays high affinity for 5-HT1B/mutant 5-HT1D β receptors by virtue of being able to form a double hydrogen bond with the asparagine residue in TM7, whereas it displays lower affinity for 5-HT1D β receptors because it can not bind to the T355 in the same manner.

STRUCTURE-ACTIVITY RELATIONSHIPS FOR CENTRAL NICOTINE RECEPTOR BINDING. D. Dumas,* M. Dukat,* W. Fiedler,* I. Damaj,* B. Martin,* R.A. Glennon. Dept. Med. Chem., MCV/VCU, Richmond, VA 23298. Nicotine (1) seems to play a role in appetite, anxiety, and various other mental disorders and is now being regarded as a template for the design of new therapeutically useful agents. We have undertaken an investigation to determine the contribution of each molecular feature of 1 to binding at central nicotine receptors. In addition, because we have demonstrated on the basis of molecular modeling studies, a significant structural relationship between nicotine and the naturally occurring high-affinity nicotine receptor ligand epibatidine (2), we have particularly focussed on 6-position substitution in the nicotine series. On the basis of these studies, several new high-affinity nicotine ligands have been developed.



TACTILE STIMULATION FOR INFANTS: DEVELOPMENT OF A GUIDE FOR NEW PARENTS. Ronda K. Hansen and James P. O'Brien, Virginia Beach Campus, Tidewater Community College, Virginia Beach, Va. 23456. Presented for review and comment is a draft pamphlet for new parents on infant massage. The importance of touch stimulation on infants (both human and animal) has been repeatedly demonstrated in over 50 years of research. On the other hand, few medical professionals consider it necessary to teach parents about the detrimental effects of touch deprivation and the significant benefits of tactile stimulation for their infants. The draft pamphlet was created to show medical and psychological research support for the importance of this practice to new parents. The draft pamphlet describes, in lay language, the infant's need for touch excerpts of the research literature with bibliography, and basic methods, and suggestions for infant massage. The pamphlet also includes photographs of infants and parents engaged in various forms of infant massage and touch. Tidewater Community College will do the first printing for distribution to Hampton Roads pediatric units as a community service.

KETANSERIN: EFFECT OF BENZYLYC MODIFICATION ON 5-HT2A AND 5-HT2C SEROTONIN RECEPTORS AFFINITY. A.M. Ismaiel,* M. Teitler,* R.A. Glennon. Dept. Med. Chem., MCV/VCU. Richmond, VA 23298. Ketanserin (KET) is a prototypical 5-HT₂ serotonin receptor antagonist. Our previous SAR study revealed that the benzylpiperidine portion of KET is important for binding, but that the remainder of the molecule can be substantially truncated. Although the truncated compounds bind with comparable affinity to KET, preliminary studies suggested that parallel structural modification of different truncated analogs resulted in non-parallel differences in receptor affinity. Accordingly, we examined a series of compounds where X = (CH₂)₂ and (CH₂)₄ and where Y and Z were varied. It is concluded that the truncated analogs bind at the receptor in a different manner depending upon the nature of Y. All compounds displayed greater 5-HT_{2A} vs 5-HT_{2C} selectivity than KET.



Lowering Zinc Concentrations to Determine the Minimum Zinc Requirements for the Growth of *Cryptococcus neoformans*. Higgs, Rebecca, Denise Hopkins*, and Judy H. Niehaus, Dept. of Biol., Radford Univ., Radford, VA 24142. *Cryptococcus neoformans*, a yeast-like organism widely distributed in nature, is an opportunistic pathogen that often infects immunocompromised patients. The present study investigates the zinc requirements of *C. neoformans*. To minimize zinc levels, glassware was washed with 12N HCl, water was purified with a mixed bed ion exchange column, and glucose was chromatographed through a Dowex 50 cation exchange resin. Preliminary studies indicated that peptone and yeast extract could be eliminated from the culture medium without adversely affecting growth rate, thereby eliminating possible sources of zinc contamination in the medium. When *C. neoformans* was cultured in minimal medium, growth was proportional to zinc concentration in the range of 1 to 35 μM zinc.

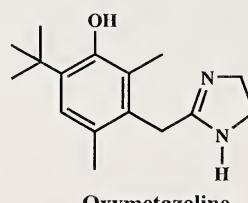
SCHISTOSOMA MANSONI: SUBCLONING AND MAPPING OF CDNA FROM THE ADULT WORM. Katherine Knight & Maryanne Simurda. Washington & Lee Univ., Lexington, VA. 24450

Clones from an adult worm cDNA library that are potentially of interest in developmental or immunological studies have been isolated and subcloned into the plasmid vector pGEM5Zf' (Promega). This project involves the generation of restriction endonuclease maps in preparation for DNA sequencing. A series of restriction endonucleases that recognize specific 6-base sites were used to digest the DNAs and the resulting fragments were analyzed by gel electrophoresis.

NOVEL CANNABINOID RECEPTOR ANTAGONIST INHIBITS ANANDAMIDE AND Δ^9 -THC INDUCED HYPOTENSION IN ANESTHETIZED RATS. Kristy D. Lake and George Kunos, Dept. of Pharmacology and Toxicology, Va. Commonwealth Univ.-Medical Col. of Va., Richmond, VA 23298. Cannabinoids (CB) affect blood pressure (BP) and heart rate (HR) in animals and humans. Our previous studies documented the cardiovascular effects of anandamide (AN) in urethane anesthetized Sprague-Dawley (SD) rats. The response to AN (1-20 mg/kg, iv) was dose-dependent and multiphasic: phase 1 bradycardia with concomitant decreased BP was mediated via central vagal activation; phase 2 pressor component was peripherally (but not sympathetically) mediated; and phase 3 hypotension resulted in a decrease in peripheral sympathetic activity. Furthermore, the CB₁ receptor antagonist (SR141716A; 0.01-10 mg/kg, iv) did not alter the pressor effect but dose-dependently ($p<0.05$) antagonized the phase 3 hypotension observed following AN or Δ^9 -THC. These data imply that the phase 3 hypotension is due to CB₁ receptor-mediated reduction of sympathetic outflow to the vasculature. We have further characterized the cardiovascular effect of AN in conscious, unrestrained normotensive SD and hypertensive SHR rats. In conscious SD rats, AN (4 mg/kg, iv) elicited bradycardia and pressor effects but no hypotension. In contrast, in both conscious and anesthetized SHR, AN elicited a triphasic BP effect with the phase 3 hypotension being slower in onset and longer in duration than in urethane anesthetized SD rats. In pentobarbital anesthetized SD rats AN elicited damped triphasic BP changes. Thus, the AN-induced hypotension is dependent on elevated intrinsic sympathetic tone.

BINDING OF OXYMETAZOLINE ANALOGS AT 5-HT1D β SEROTONIN RECEPTORS. H. Law,* M. Dukat,* R. Kamboj (Allelix),* R.A. Glennon. Dept. Med. Chem., MCV/VCU, Richmond, VA 23298. Oxymetazoline, an adrenergic receptor ligand, has been demonstrated to bind with high affinity ($K_i = 1 \text{ nM}$) at 5-HT1D β serotonin receptors. As such, it serves as a novel template for the design of new 5-HT1D β ligands.

Keeping the imidazoline portion of the molecule intact, we examined the contribution to binding of each of the aryl substituents by synthesizing and evaluating various mono-, di-, tri-, and tetra-substituted analogs. Structure-affinity relationships have been formulated which should aid in the subsequent design of high-affinity and more selective 5-HT1D β receptor agents.



Oxymetazoline

IMMUNOTOXIC EFFECTS OF COBRA VENOM FACTOR (*Naja Haje*) ON C3 AND ISOTYPE SWITCHING AS EVALUATED BY ELISA. G. Craig Llewellyn¹, Leon F. Butterworth*¹, & Kimber L. White Jr.^{1,2}, Depts. of Pharmacology and Toxicology, & Biomedical Engineering², Med. Col. of Va., Va. Commonwealth Univ., Richmond, VA. 23298-0613. Environmental immunotoxins such as 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and pentachlorophenol have been shown to have detrimental effects on C3, a component of the complement system and humoral immune responses. Genetically C3 deficient animals and humans lack the ability to undergo immunoglobulin isotype switching and have been shown to be prone to recurrent infections. This study was undertaken to determine if compounds capable of altering C3 levels have the potential to modulate isotype switching to a T-dependent antigen, sheep erythrocytes (sRBC). Cobra venom factor (CVF), a known C3 depleting agent, was evaluated for its ability to decrease C3 levels and modulate isotype switching, following sensitization with low (10⁶ sRBC) and high (7.5x10⁷ sRBC) concentrations of antigen. Female B6C3F1 mice were intravenously injected with saline, 1, 10, or 100 anticomplementary units (ACU)/kg, and serum C3, IgM, and IgG titers evaluated by ELISA. A decrease of 20%, 29%, and 84% in C3 levels was observed with the low antigen concentration, and a decrease of 7%, 54%, and 87% in C3 levels was observed with the high antigen concentration following 1, 10, and 100 ACU/kg doses of CVF. In the primary IgM response, a dose dependent increasing titer was observed following both low and high antigen challenge. Statistical significant differences were observed only at the 10 and 100 ACU/kg doses of the high antigen groups. In the secondary IgG response, the animals receiving high antigen challenge and CVF did not differ from the saline control. However with the low antigen challenge, a decrease of 58%, 60%, 76% was observed in animals receiving 1, 10, and 100 ACU/kg CVF. Animals receiving a low concentration of antigen and having a significant decrease in C3, also showed a significant decrease in IgG response. As was observed with the genetically deficient C3 animals, isotype switch was decreased following CVF administration and low antigen challenge. However, the inability to isotype switch was overcome when a high antigen concentration was utilized.

THE EFFECTS OF ACUTE AND CHRONIC ADMINISTRATION OF CI-977 ON [³H] -NITRENDIPINE BINDING IN MOUSE BRAIN AND SPINAL CORD TISSUE. David J. Mason Jr. and Sandra P. Welch. Department of Pharmacology and Toxicology, Medical College of Virginia/Virginia Commonwealth University, Richmond, VA 23298. Kappa (k) receptor agonists have been shown to produce antinociception with fewer side effects than morphine and other μ -agonists. Studies indicate that acute administration of k-agonists produce a decrease in calcium conductance via the voltage sensitive calcium channels. We investigated the effects of acute and chronic administration of the k-agonist, CI-977, on the voltage gated L-type calcium channels. Acute administration consisted of a single i.p. administration of CI-977. Tolerance was developed by a 3 day regimen consisting of a 5 mg/kg i.p. dosage delivered twice daily at 8:00 a.m. and 4:00p.m. on days 1 and 2 followed by a 10 mg/kg i.p. dosage on day 3. Neither acute nor chronic administration of CI-977 produced significant alterations in [³H] - nitrendipine affinity or maximal binding in mouse whole brain homogenates. Acute administration of CI-977 produced no significant changes in [³H] - nitrendipine binding or affinity in mouse spinal cord homogenates. These data indicate that L-type calcium channels may not be involved in k-tolerance in the brain. (Supported by NIDA grants DA06031 and DA07027.)

THE EFFECTS OF ACUTE AND CHRONIC ANABOLIC ANDROGENIC STEROID TREATMENT ON DIFFERENT LOCOMOTOR STIMULANTS. Sean D. McAllister and David Compton. Dept. of Pharm/Tox, MCV, Richmond VA 23298-0613. Previous studies have indicated an interaction between anabolic-androgenic steroid (AAS) treatment and the locomotor stimulatory effect of cocaine. This investigation evaluated the effect of AAS treatment on differing classes of stimulants. Male ICR mice were treated (i.p.) acutely or chronically (4 weeks) with testosterone propionate (TP) or sesame oil (veh). An hour after the acute or last chronic TP injection, mice were administered various stimulants and evaluated for locomotor stimulation. Dose response curves were generated for cocaine (COC), amphetamine (AMP), amfonelic acid (AFA) and caffeine (CAF) following acute AAS treatment and for COC following chronic AAS treatment. The Emax and ED₅₀ were determined from the stimulatory portion of the dose response curves utilizing sigmoidal curve linear analysis. Acute TP treatment significantly reduced the Emax (counts) of COC (7016 to 4492) and AFA (8433 to 6106) but not CAF (3501 to 3300). Chronic AAS treatment did not significantly reduce the Emax of COC (8555 to 7448). The ED₅₀ values of treatment groups did not differ from controls. These data indicate that acute AAS treatment decreases the maximum stimulatory effect of some, but not all, stimulants and chronic AAS treatment might induce some degree of tolerance. Supported by NIDA grant DA-07507.

TAXOL-MEDIATED CHANGES IN FIBROSARCOMA-INDUCED MACROPHAGE FUNCTION: DOWNREGULATION OF IMMUNOSUPPRESSION AND ENHANCED ANTITUMOR ACTIVITIES. D.W. Mullins and K.D. Elgert. Dept. of Biol., Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061-0406. Tumor-bearing host (TBH) macrophages ($M\phi$) mediate immunosuppression, in part, through overproduction of nitric oxide (NO) and tumor-necrosis factor-alpha (TNF- α). In tumor-distal sites, NO and TNF- α suppress T cell proliferation but lack anti-tumor activities. Because taxol stimulates $M\phi$ activities and tumor growth induces functional changes among $M\phi$ populations, we studied whether murine fibrosarcoma growth altered taxol-mediated regulation of $M\phi$ activities. Activated normal host (NH) $M\phi$ produced less NO than did TBH $M\phi$; taxol pretreatment increased NO production by NH $M\phi$ but decreased TBH $M\phi$ NO production. Taxol increased TNF- α production by NH and TBH $M\phi$. Exogenous TNF- α decreased NO production by activated $M\phi$ populations, and neutralization of TNF- α activity increased NO production by activated $M\phi$ but blocked taxol-mediated downregulation of TBH $M\phi$ NO production. This suggests that TNF- α may autocrinely regulate $M\phi$ NO production and taxol may suppress TBH $M\phi$ NO synthesis through TNF- α . Taxol-pretreated TBH $M\phi$ were less suppressive of T cell proliferation, suggesting that taxol-mediated downregulation of NO production may partially reverse tumor-induced immunosuppression. Although tumor growth primes $M\phi$ for increased NO and TNF- α production, taxol may regulate these suppressive molecules in tumor-distal locations, partially reversing tumor-induced immunosuppression. The success of taxol as an anticancer agent may partially derive from its immunotherapeutic efficacy.

N-GLUCURONIDATION OF PHENOBARBITAL: *IN-VITRO* STUDIES IN HUMAN AND MOUSE LIVER MICROSOMES. Sheela G. Paibir, William H. Soine, Diana Thomas and Robert A. Fisher[#], Dept. Medicinal Chemistry and Dept. Surgery[#], MCV/VCU, Richmond, VA-23298. Phenobarbital *N*-glycosides (PbG) are urinary metabolites of phenobarbital (Pb) in mouse and human. Studies on the formation of PbG conjugates required the development of an *in-vitro* assay for Pb *N*-glucuronidation using liver microsomes. Co-incubation of the liver microsomes from either the mouse or the humans with Pb and [14 C]-UDP-glucuronic acid (UDP-GA), led to the formation of radiolabeled (*R*)- and (*S*)-Phenobarbital *N*-glucuronide (PbGA). The glucuronidation activity of the native liver microsomes was increased 5-fold and 2-fold by CHAPS in the mouse and the human, respectively. In both species, PbGA formation was optimal over a pH ranging from 6.5-7.3; and in the presence of magnesium. Presence of saccharolactone, a β -glucuronidase inhibitor showed no increase in the specific activity. The K_m (mM) and V_{max} (picomoles/mg-prot/min), respectively, for Pb (presence of 200 μ M UDP-GA), were 3.52 ± 0.50 and 7.74 ± 0.51 (male mouse), 1.04 ± 0.15 and 1.23 ± 0.05 (human male), 1.57 ± 0.24 and 0.91 ± 0.05 (human female). The K_m and V_{max} , respectively, for UDP-GA (presence of 5 mM Pb), were 1.15 ± 0.18 and 8.67 ± 0.51 (male mouse), 0.41 ± 0.04 and 4.98 ± 0.15 (human male), 0.095 ± 0.018 and 1.14 ± 0.05 (human female). These studies demonstrate that PbGA is biosynthesized by both the mouse and the human liver microsomes *in-vitro* with comparable enzymatic characteristics. (Supported by NIH Grant GM 34507).

A COMPARISON OF *N*-GLUCOSYLATION AND *N*-GLUCURONIDATION OF PHENOBARBITAL IN HUMAN LIVER MICROSOMES. Sheela G. Paibir, William H. Soine, Diana Thomas and Robert A. Fisher[#], Dept. Medicinal Chemistry and [#]Dept. Surgery, MCV/VCU, Richmond, VA-23298. Phenobarbital *N*-glucoside (PbG) and phenobarbital *N*-glucuronide (PbGA) are formed *in-vitro* by mouse liver microsomes co-incubated with phenobarbital (Pb). Typically, biosynthesis of glucoside and glucuronide conjugates is catalyzed by UDP-glucosyltransferase(s) and UDP-glucuronyltransferase(s) enzymes, respectively. The radiochemical assay developed to study these glycosylation pathways *in-vitro* in the liver microsomes of mouse was extended to the humans. The conjugation activities of the liver microsomes were analyzed from 18 humans (12 males, 6 females) aged from 7-69 years. Presence of CHAPS increased Pb *N*-glucuronidation but decreased Pb *N*-glucosylation. The average specific activities for the formation of PbG (no detergent) and PbGA (1 mg-CHAPS/mg-prot.), in the presence of 2 mM Pb, were 1.30 ± 0.93 and 1.03 ± 0.59 picomoles/mg-prot/min, respectively. The observed activities for either PbG or PbGA formation did not appear to correlate to prior drug exposure, bilirubin levels, race, age or sex of the patient. The ratios of V_{max}/K_m for Pb in two males were 3.93 and 0.86 for PbG formation, and 1.18 and 1.63 for PbGA formation; and in two females were 0.47 and 0.42 for PbG, and 0.20 and 0.58 for PbGA. The mean of the ratios of the *in-vitro* specific activities for PbG and PbGA formation was 1.51 ± 0.93 , suggesting that Pb should undergo *N*-glucosylation and *N*-glucuronidation to a comparable extent in humans *in-vivo*. (Supported by NIH Grant GM 34507).

DIFFERENTIAL EXPRESSION OF NEURONAL NICOTINIC RECEPTOR $\alpha 4$ SUBUNIT mRNA IN RAT BRAIN. J. J. Shacka and S. E. Robinson*, Dept. of Pharmacology & Toxicology, Med. Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23298-0613. The goal of this study was to compare neuronal nicotinic receptor (nNR) $\alpha 4$ subunit mRNA development in Sprague-Dawley CD rat brain. 50 μ g total RNA from adult or three-week old hippocampus (hippocampus+septum), cortex and thalamus was size-fractionated and transferred to nitrocellulose. Northern hybridization was performed via an α -32P dCTP-labelled 200 bp probe encoding the non-conserved 3' intracellular loop of nNR $\alpha 4$ -1 subunit cDNA. Total RNA was normalized for gel loading via γ -32P ATP-labelled 28S rRNA. Data were quantified via Molecular Dynamics intensity units as the ratio of $\alpha 4$ mRNA to 28S rRNA. Preliminary studies have identified three transcripts (8.5, 4.2 and 2.4 kb) homologous to $\alpha 4$ -1 cDNA, with similar quantities in both age groups. Upon normalization, the 8.5 kb transcript was more pronounced in the thalamus than in the cortex, and barely detectable in the hippocampus. The ratio of the 4.2 kb transcript to 28S was greater in the thalamus than in the cortex or hippocampus, which had similar ratios. The ratio of the 2.4 kb fragment to 28S was higher in the thalamus than in the cortex, and much lower in the hippocampus. These findings suggest brain region-specific processing of multiple transcripts encoding the $\alpha 4$ subunit in rat brain.

INVESTIGATION OF THE CANNABINOID ANTAGONIST, CP330,947. Lori Showalter, and Aron Lichtman, Dept. of Pharmacology and Toxicology, Va. Commonwealth Univ., Richmond, Va. 23284. It is well established that the cannabinoid agonist, CP 55,940 produces antinociception, hypothermia and catalepsy in rodents. The purpose to this study was to examine the effects of pretreatment of CP 330,947, a putative antagonist of the brain cannabinoid receptor, on the pharmacological effects of cannabinoids. Rats were implanted with intracerebroventricular (ICV) cannula guides directed at the left lateral ventricle. After a one week recovery period, the animals were given two ICV injections; the first was dimethyl sulfoxide (DMSO) vehicle or CP 330,947 (100 or 300 μ g) and ten minutes later each animal was given DMSO or CP 55,940 (10, 25, 35, 50, 100 or 300 μ g). The antinociception and cataleptic effects of CP 55,940 were blocked by CP 330,947. The ED50 for antinociception of CP 55,940 alone was 22 μ g, 100 μ g of CP330,947 decreased this antinociceptive effect two fold (ED50 = 47), and 300 μ g of CP 330,947 completely blocked the antinociceptive effects of CP 55,940. These findings support the contention that CP 330,947 is a cannabinoid antagonist.

ANABOLIC STEROID ALTERATIONS OF ANDROGEN RECEPTOR mRNA LEVELS IN THE BRAIN. Suzanne R. Thornton, Mary E. Abood and David R. Compton, Dept. Pharm/Tox., Med. Col. of Va., Richmond, Va. 23298. Anabolic steroid abuse has dramatically increased, prompting the passage of the Anabolic Steroid Control Act of 1990. Although their abuse has increased, little has been done to characterize molecular and biochemical alterations in the central nervous system during their abuse. The present study was conducted to determine if androgen receptor mRNA could be detected in the brain and to determine the effects of acute and chronic anabolic steroids on androgen receptor mRNA levels. The study was conducted using male ICR mice (weighing 25-30 g) injected I.P. with either sesame oil or sesame oil with 5 % benzyl alcohol or 500 mg/kg of nandrolone deconate, nandrolone propionate, testosterone deconate and testosterone propionate. The acute steroid treatment groups were sacrificed one hour after injection while the chronic steroid treatment groups were treated for four weeks and sacrificed one hour after their final injection. Animals were decapitated and whole brains removed and prepared for Northern blot analysis. An 11 kb and a 9.3 kb androgen receptor mRNA band was detected using a rat androgen cDNA probe. Alterations in one or both of the mRNA species was observed in the acute and chronic steroid treated groups. These data are the first indication that androgen receptor mRNA species can be detected in brain tissue. Also, steroids administered acutely or chronically can cause alterations in the androgen receptor which could alter receptor expression or could be related to the clinical reports of sexual, motor and psychological disturbances in anabolic steroid abusers.

BLOCKADE OF KETOROLAC-INDUCED ANTINOCICEPTION BY NOR-BINALTORPHIMINE IN MICE. Anubha Tripathi and Sandra P. Welch, Dept. of Pharmacology and Toxicology, Medical College of VA, VA Commonwealth Univ., Richmond, VA 23298. The antinociceptive effects of ketorolac, administered intracerebroventricularly, were determined in mice by measuring inhibition of the p-phenylquinone-induced effects of abdominal stretching. The ED₅₀ value for ketorolac in the p-phenylquinone test was determined to be 7.34 µg/ mouse (4.97-10.82). Antinociceptive activity produced by ketorolac was found to be dose-dependent. Selective antagonists of the μ , δ , and κ -opioid receptors were used to determine ketorolac's mechanism of action. The antinociceptive effects produced by ketorolac were not blocked by the μ -opioid receptor antagonist, naloxone, and the δ -opioid receptor antagonist, ICI-174,864; however, nor-BNI, the κ -opioid receptor antagonist, significantly blocked these effects. These results suggest that the stimulation of κ receptors appears to play a role in the mechanism of action of the antinociception produced by ketorolac. In addition, ketorolac may cause the release of endogenous κ opioids to create central nervous system antinociception.

GLUTATHIONE AND PLANARIAN REGENERATION. R. B. Worobec, P.O.B. 162, Mt. Vernon, VA 22121-0162. Glutathione (GSH; L- γ -Glu-Cys-Gly), the most important and ubiquitous nonprotein thiol in living systems, is directly or indirectly involved in a wide spectrum of biological phenomena, including cell proliferation and tumorigenesis. Since planarians are recognized for their prodigious regenerative powers, they constitute an excellent model--within limitations--for assessing cell activation and proliferation. Studies from half a century ago, while ambiguous, indicated that GSH levels fluctuate in the course of planarian regeneration, and that exogenous GSH may enhance regeneration and fissioning. Accordingly, preliminary screening studies were undertaken with laboratory-bred asexual *Dugesia tigrina* to ascertain the effect of exogenous GSH on the rate of regeneration and fissioning of worms maintained at room temperature ($21 \pm 3^\circ$) in spring water, pH 7.51. Observations on one population of sectioned 8-12 mm *Dugesia tigrina* gave the impression that the rate of regeneration was not affected by exogenous GSH (20-80 µg/ml); however, tail segment fissioning was enhanced prior to full head regeneration. After 8 days 100% of the tail segments exposed to 40 µg/ml GSH had fissioned, 65% of those exposed to 20 µg/ml GSH, and none of the control tails. In order to further define the role of GSH in planarian regeneration, studies are underway with L-buthionine-SR-sulfoxime, a specific inhibitor of γ -glutamylcysteine synthetase, and GSH monomethyl ester (for efficient delivery) to more effectively modulate intracellular GSH concentrations in planaria.

Microbiology and Molecular Biology (No Abstracts Submitted)

Natural History and Biodiversity

FIRE HISTORY OF THE GEORGE WASHINGTON NATIONAL FOREST. H. S. Adams, D. S. Lancaster Cnnty. Col., Clifton Forge, VA 24422 and S. Croy, USDA For. Serv., Roanoke, VA 24019. Data were obtained from records for 2,198 fires occurring in the George Washington National Forest through 1993. Whenever available, elevation, aspect, topographic position, size, forest type, and cause of each fire were noted. Sixteen possible "causes" of fire were categorized, most (21%) due to arson. Smoker-related fires accounted for an additional nineteen percent, "unknown" origin for fourteen percent, and lightning for thirteen percent. Forty-eight percent of all fires during the year occurred in March, April (alone, 26%), and May with another fifteen percent in November. Of the fifty-nine fires (2.7 percent of all fires) that were five hundred or more acres in size, eighteen (thirty percent) were attributed to arson. The largest lightning-caused fire was 640 acres, occurring in May, 1925. Forty percent of the largest fires (for which records were available) occurred in April and another twenty percent in November. Nearly 50 fires per year (higher than for other decades) occurred during the 1970s and 1980s with arson origin peaking in the 80s. Fires attributed to camping have steadily increased since the 1950s. In general, fires due to lightning tended to occur during months with more precipitation (June - August) and vice versa for fires attributed to other causes. Based on our data, the most likely "strike zone" in the GWNF for lightning fires is southeast or southwest upper slopes or ridgetops in an elevational range of 1,600 to 3,200 feet. (This study was supported in part by funds provided by the USDA Forest Service.)

REARING OF JUVENILE FRESHWATER MUSSELS IN AN ARTIFICIAL STREAM SYSTEM. Braven B. Beatty & Richard J. Neves, NBS Cooperative Research Unit, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061. An experimental system for rearing juvenile freshwater mussels (Unionidae) has been developed and designed with natural river water supplied to the animals. The artificial stream beside the Clinch River at the Clinch River Steam Plant in Carbo, VA ensures that the food and chemical composition of the water overlying the juveniles is similar to that experienced in rivers. The streams consist of oval tanks with center islands, and paddlewheels continuously provide a unidirectional current in the tanks. Juveniles were placed in the tanks in small containers so that they could be located by researchers during the experiment. In June, 1993, 18 containers with 100 juvenile rainbow mussels (*Villosa iris*) each were placed in the artificial streams in one of two substrate sizes (< 120 μm and between 120 and 600 μm). The animals were allowed to grow for 4.5 months, after which survival rates and growth were measured. Neither survival rate nor growth was statistically different between the substrate sizes. Mean survival rates were 27.7% and 27.3% for the fine and coarse substrate, respectively. Mussels in the fine substrate attained a mean size of 10.8 mm², while those in the coarse substrate reached a mean size of 8.9 mm². The experiment was modified in 1994 to include the same two substrate sizes and two substrate depths, 5 mm and 20 mm. In September, 1994, 80 containers with 100 juveniles each were placed in the artificial streams. The animals were allowed to remain in the streams for 3 months. These animals had survival rates of less than 3% and exhibited no growth. We believe that the late start for this experiment, the resulting low water temperatures, or other factors contributed to this poor performance.

SYSTEMATICS OF THE SPIDER GENERA *MALLOS* AND *MEXITILIA* (ARANEAE: DICTYNIDAE). Jason E. Bond, Dept. of Biol., Virginia Polytechnic Institute and State University, Blacksburg, VA 24061. This systematic study recognizes 15 species of the genus *Mallos* Pickard-Cambridge and three species of the genus *Mexitilia* Lehtinen. Three species of *Mallos* and one species of *Mexitilia* are newly described. Two *Mallos* species are placed in synonymy and two species are transferred to other dictynid genera. The males of two *Mallos* species are described for the first time. A cladistic analysis based on 22 morphological characters produced a cladogram that supports the monophyly of *Mallos* and the validity of *Mexitilia*. For five species of *Mallos* and one species of *Mexitilia* mitochondrial and nuclear DNA sequences were analyzed by restriction digest. The seventeen resulting restriction sites produced a cladogram that agreed with the one based on the morphology of these six species. When morphological and molecular characters were combined they produced a single tree that was identical to that based on molecular data alone. These molecular and morphological characters present the same picture of *Mallos* and *Mexitilia* phylogeny. (Supported by: Sigma Xi, American Museum of Natural History, GSA Virginia Tech., Dept. of Biology Virginia Tech., and Promega)

THE SOUTHERN WATERSHEDS COMMON REED PROJECT: MANAGEMENT OF AN INVASIVE PLANT. Kennedy H. Clark, Va. Dept. of Conservation and Recreation, Div. of Natural Heritage, 1500 E. Main St., Suite 312, Richmond, VA 23219. Common reed (*Phragmites australis*) is an invasive wetland grass which has become especially pernicious in the Southern Watersheds, an area in the southeastern corner of Virginia. Common reed is a threat to many of the rare species and the exemplary marsh communities of the Southern Watersheds because its aggressive growth patterns displace native plants and degrade wildlife habitat. In order to address the common reed problem, the Virginia Department of Conservation and Recreation along with many partners began a two-year project in 1993 designed to demonstrate effective control of common reed on stands which are imminently threatening some of the more significant marshes of the Southern Watersheds. The project, which will conclude at the end of 1995, entails a site selection phase, control of common reed through herbicide application and prescribed burning, quantitative vegetation monitoring, public education initiatives, and a cooperative comprehensive planning effort among the conservation interests of the Southern Watersheds.

RECENT EXOTIC INSECT INTRODUCTIONS OF ECONOMIC IMPORTANCE: 1985-1995. Eric. R. Day, Department of Entomology, VPI&SU, Blacksburg, VA 24061-0319. Exotic insects are defined as insects with a native range outside of Virginia or the North American continent. Introductions are successful establishments of these insects in the Commonwealth. The Asian Tiger Mosquito, Western Corn Rootworm, Multicolored Asian Lady Beetle, *Misanthus* Mealybug, and Beech Scale all have established themselves in Virginia in the last decade. These insects have varying degrees of importance and spread in Virginia. Two other insects are also discussed, the gypsy moth which continues its southward spread and the boll weevil which has been eradicated from Virginia allowing many growers to try growing cotton again. Exotic detection programs are also discussed.

RELIABILITY AND EFFICIENCY OF MORPHOLOGICAL INDICES OF SALAMANDER NUTRITIONAL CONDITION. Kevin L. S. Drury, Douglas N. Harpole, and Carola A. Haas. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061. Estimating the nutritional condition of animals in the field may be useful for determining health of populations. We maintained 84 red-backed salamanders (*Plethodon cinereus*) in the lab on different diets. We then measured morphological characters that have been used as indices of condition. The measurements were: 1) mass/SVL(snout-vent-length), 2) vol/SVL, and 3) tail width (TW)/SVL. We timed investigators taking the measurements and tested the techniques for differences in efficiency using the Kruskal-Wallis k-test. The TW/SVL measurement was most efficient with a mean time of 42.5 sec. Mass/SVL was next at 48.6 sec and vol/SVL was least efficient at 114.1 sec. Additionally, we compared changes in volume to changes in mass and found no significant difference between the two ($p>0.61$). Results from changes in TW were inconclusive and are under further study.

RECONNAISSANCE VEGETATION STUDY OF FOUR RIVER GORGES IN WEST VIRGINIA. R. H. Fortney*, Dept. of Nat. Sci. and Math, Salem-Tekyo Univ., Salem WV 26426, S. L. Stephenson, Dept. of Biology, Fairmont State College, Fairmont, WV 26554, and H. S. Adams, D. S. Lancaster Cmnty. Col., Clifton Forge, VA 24422. During the 1994 field season, we collected quantitative data on composition and structure of the vegetation in the Bluestone, Gauley, Meadow, and New River Gorges of West Virginia. A single transect was located on a representative slope of each gorge (except Meadow River) and at least three twenty by fifty meter (0.1 ha) quadrats (with smaller nested quadrats) were established equidistantly along this gradient to sample vegetation. Tree core and soil samples also were collected in or near each quadrat. Additional cores were obtained from trees growing at selected rock outcrops in the Gauley, New, and Meadow River Gorges. Dry site oak-dominated forests generally occupied the upper slopes, whereas more mesophytic forests were found down slope. Levels of pH and concentrations of Ca, N, Mg, Mn, K, and P typically increased along this same gradient. The finding of trees exceeding 250 years at the Carnifex Ferry State Park site in the Gauley River Gorge and in a stand located on a very steep midslope between two rock outcrops in the Bluestone Gorge suggests possible existence of other old-age trees in these steep gorges. (This study was supported by the National Park Service.)

TERRESTRIAL SALAMANDER DENSITY AND DIVERSITY IN THE MOUNTAINS OF SOUTHWESTERN VIRGINIA. Douglas N. Harpole and Carola A. Haas. Dept. of Fisheries and Wildlife Sciences. Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. As part of an ongoing study to examine the effects of silvicultural practices on biodiversity in the southern Appalachians, we sampled terrestrial salamander populations at five sites in the Jefferson National Forest. From April through October of 1994, we sampled one 14 ha study area in each of the Newcastle, Blacksburg, and Wythe ranger districts and two in the Clinch ranger district. We used night searches of 2x15 m transects to determine species richness and relative abundance. The number of species encountered on each site ranged from 4 to 12. Mean densities of animals captured on transects ranged from 0.01 individuals per m^2 at the Newcastle site to 0.74 individuals per m^2 at one Clinch site.

ECOLOGY OF SCALE INSECTS IN VIRGINIA. Michael Kosztarab, Dept. of Entomology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061. Abiotic conditions such as high humidity, summer heat and drought, wind velocity, and heavy rains adversely affect most scale insects. Some scale insects are adapted to saltwater inundation, and to nutrient abundance or deficiency in the soil and/or in their host plants. These insects have adapted to a variety of biotic conditions, including most terrestrial macrohabitats having plant life, and they also occupy special microhabitats. A number of unique plant-host associations are discussed, including host induced biotypes, such as stem and leaf forms. Their parasites and predators are also presented, and their mutualistic relationship with ants discussed.

FIELD STUDIES ON THE SEX RATIO AND SEXUAL DIMORPHISM OF WESTERN CORN ROOTWORM. Thomas P. Kuhar, Dept. of Entomology, VPI & SU, Blacksburg, Va 24061-0319. Field studies were conducted in 1993 to investigate a possible sexual dimorphism in the elytra coloration pattern of western corn rootworm, *Diabrotica virgifera virgifera* LeConte, adults, and to compare the sex ratio of adults captured on two commercial yellow sticky traps with those obtained by aspiration. Striped and solid variations in elytra pattern were found in both sexes. Of the western corn rootworm adults which exhibited the solid elytra pattern, over 99% captured on yellow sticky traps and 97% collected by aspiration were male. In contrast, of those adults which exhibited the striped elytra pattern, 79% captured on yellow sticky traps and 42% collected by aspiration were male. Sex ratio of adults varied significantly over time and among sampling methods. Sticky traps captured a significantly greater proportion of males compared with aspiration. No significant difference in sex ratio was found between the two brands of sticky traps, however, the Olson trap captured significantly more corn rootworm adults overall than the modified Pherocon AM trap.

DISTRIBUTION OF FISH ABOVE AND BELOW A HYDROLOGICAL BARRIER IN THE RUSSELL FORK, VIRGINIA. Kevin N. Leftwich, U.S. Forest Service, Dept. of Fish. and Wildl. Sci., Virginia Tech, Blacksburg, VA 24061-0321, William E. Ensign* and Paul L. Angermeier*, Virginia Coop. Fish and Wildl. Res. Unit, Dept. of Fish. and Wildl. Sci., Virginia Tech, Blacksburg, VA 24061-0321. We used electrofishing and underwater observation techniques to determine fish distribution in 16 river-kilometers (divided into four segments) of the Russell Fork (Big Sandy drainage) in Fall of 1994. Twenty-eight species were captured or observed in the study area. Species richness increased from 12 species in the upstream segment to 22 species in the downstream segment. The change in species richness primarily occurred at a series of cascades and waterfalls located within an area one kilometer upstream from the Virginia-Kentucky border. Six species (Moxostoma sp., Percina caprodes, P. maculata, Etheostoma zonale, E. blennioides, and Stizostedion vitreum), observed only below these falls, are new records for the Russell Fork in Virginia. (Supported by funding from the U.S. Army Corps of Engineers)

TECHNIQUES OF VIDEOTAPING FISHES FROM ABOVE THE SURFACE OF THE WATER. Eugene G. Maurakis, Science Museum of Virginia, Richmond, VA 23220 and William S. Woolcott, University of Richmond, VA 23173. Few biologists have successfully taped activities of fishes in streams from above the surface of the water. This presentation describes the cameras, recorders, power supply, lighting sources, cinematographic techniques (camera angle, continuity, cutting, close-ups, composition), recording methods, and analytical techniques that we have used to videotape reproductive behaviors of fishes from above the surface of the water. Prior to our use of frame-by-frame analysis of videotapes beginning in 1986, not a single author had reported 20 conspicuous reproductive behaviors that we now have identified and categorized into sequences of behavior for over 35 species in 375 hours of recordings. Species-specific behaviors can be used as effective management tools in preserving habitats of species as they directly relate to the habitat requirements of species. Funded by University of Richmond, and Richard and Carolyn T. Gwathmey Memorial Trust.

LOW REPRODUCTIVE SUCCESS OF A NEOTROPICAL MIGRANT SONGBIRD IN AN EXTENSIVELY FORESTED LANDSCAPE. Amy L. Meehan and Carola A. Haas, Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. & State Univ., Blacksburg, VA. 24061-0321. One year of preliminary data collected on a site in an extensively forested landscape in Virginia indicated low reproductive success for solitary vireos (*Vireo solitarius*). The Mayfield estimate of nest success was 12% as compared to an average of 42% for Neotropical migrants (Martin 1992). Fall cankerworm (*Alsophila pometaria*) defoliation and some ice storm damage created a relatively open canopy in the summer of 1994. The increased visibility of nests to predators and parasites may be responsible for the depredation rate of 47% and the cowbird (*Molothrus ater*) parasitism rate of 23%. Pairing success, however, was 88%, indicating that females did settle in this habitat, despite the low rate of nesting success.

CARABID BEETLE BIODIVERSITY IN CONTRASTING HABITATS IN NORTHERN VIRGINIA. Adrienne A. Hall & Joseph C. Mitchell, Dept. of Biology, Univ. of Richmond, VA 23173, and Richard L. Hoffman, Virginia Museum of Natural History, 1001 Douglas Ave., Martinsville, VA 24112. We studied the composition and structure of ground beetle communities in Quantico Marine Corps Base, Prince William and Stafford counties, Virginia for two six-week periods: 30 August - 11 October 1990 (Fall sample) and 17 April - 29 May 1991 (Spring sample). Three-armed drift fence arrays with a 19 l plastic bucket at each end of each 7.5 m arm of aluminum flashing (6 pitfalls per array) were established in two riparian hardwood forest sites, two upland hardwood sites, and two old field sites. The 3041 individual captures represented 35 genera and 71 species. Number of species per site varied from 26 in an upland hardwood forest to 39 in a field consisting of grasses and two-year old loblolly pine. Except for this site (spring 32, fall 19), the number of species between spring and fall samples did not differ significantly. Shannon diversity indices were similar among sites and seasons. Our measures of microhabitat diversity exhibited no relationships with measures of beetle community structure. Evaluating beetle communities at the family level yielded no substantive inferences. However, 15 of 21 species occurring only in hardwoods are in mesic and hydrophilic-adapted genera and 7 of 12 species found only in old fields are in xeric-adapted genera. Inferences on the effects of habitat disturbance to carabid beetle communities should be made at the generic level.

CHEMOSENSORY ABILITIES OF FEMALE FRESHWATER MUSSELS (UNIONIDAE).

William F. Henley and Richard J. Neves, Va. Cooperative Fish and Wildlife Res. Unit, Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061-0321. Behavioral changes in gravid *Lampsilis fasciola* and *Villosa iris* indicate their ability to detect host (*Micropterus dolomieu*) and non-host (*Cyprinus carpio*) fishes and mucus. Behavioral observations of adult mussels included degree of mantle presentation, mantle pulse rate, glochidial ejection, shell spread, and inhalant aperture length. Measurements associated with these observations were used to create a composite behavioral index. *Lampsilis fasciola* was more active with exposure to host fishes and mucus ($p < .00001$ and $p < .0001$, respectively), and less active with exposure to non-host fishes ($p < .00001$). Also, activity levels were higher with exposure to host fishes than mucus ($p < .00001$). Similar behavioral changes were noted with *V. iris*. *L. fasciola* was found to be more active diurnally, whereas *V. iris* was found to be more active nocturnally.

OLD GROWTH FORESTS OF PETERS MOUNTAIN, ALLEGHANY COUNTY, VIRGINIA. William H. Moorhead III. Va. Dept. of Conservation and Recreation, Div. of Natural Heritage, Main Street Station, 1500 E. Main St., Suite 312, Richmond, Va. 23219. Two large stands of primary, old-growth Appalachian oak forest, totaling 1400 ha. were unexpectedly discovered in 1994 on Peters Mountain in the George Washington and Jefferson National Forests. The discovery was made during a cooperative research project between the Virginia Dept. of Conservation and Recreation and USDA Forest Service. The project resulted in the establishment of 50 0.04-ha permanent plots used to classify and map the vegetation and ecological land units of a 4050 ha study area which represented a typical Ridge and Valley Province landscape. Plot sampling documented total floristic composition, vegetation structure, 14 environmental variables including soil chemistry, and the aging of the largest trees present. Dominant canopy trees with trunk diameters between 43 and 81 cm were 150–300 years old. Other large stands of old-growth forest are likely to exist in Virginia, especially on poorer mountain sites where the canopy trees aren't especially large, but comprise pristine or nearly pristine forest conditions.

DISCOVERY OF SHALE BARRENS IN THE BLUE RIDGE MOUNTAINS OF WEST-CENTRAL VIRGINIA. Thomas J. Rawinski, Va. Dept. of Conservation and Recreation, Div. of Natural Heritage, Main Street Station, 1500 E. Main St., Suite 312, Richmond, Va. 23219, Edith Beck, 1405 Landon Ct., Lynchburg, Va. 24503, & Kenneth Hickman, George Washington and Jefferson National Forests, Box 10, Rt. 130, Natural Bridge Station, Va. 24579. Shale barrens are natural environments supporting xerophytic vegetation characterized by several endemic, near-endemic, and disjunct plant species. Shale barrens were thought to occur only in the Ridge and Valley physiographic province, but brief accounts in the literature, plant collection records, and subsequent field sampling confirm the occurrence of shale barrens in the Blue Ridge Mountains of Rockbridge and Botetourt Counties. These barrens occur on steep, south-facing slopes of the Harpers Formation. Typical rocks are metasandstone, metasiltstone, and phyllite. Four distinct subassociations of the *Pinus virginiana*-*Quercus montana*/*Senecio antennariifolius* Association were classified, which demonstrated overall similarity to the Ridge and Valley barrens. The Blue Ridge shale barrens are distinguished by the consistent absence of most shale barren endemics. Additional biological inventory, ecological study, and site protection are recommended.

OLD-GROWTH FORESTS IN THE MID-APPALACHIANS. S. L. Stephenson, Dept. of Biology, Fairmont State Col., Fairmont, WV 26554 and H. S. Adams, D. S. Lancaster Cmnty. Col., Clifton Forge, VA 24422. Areas of upland forest that apparently escaped logging are uncommon in the mid-Appalachians, but a few examples do exist. One of the largest and best known of these is the Gaudineer Scenic Area (a mixed northern hardwood/red spruce community) on Cheat Mountain in West Virginia. Other examples include two sites, Pond Drain (a mixed mesophytic community) and War Spur Branch (a hemlock/red spruce community), on Salt Pond Mountain in southwestern Virginia, and Turkey Run (red spruce/hemlock community) on McGowan Mountain in West Virginia. Throughout the region, individual trees of sufficient age (>150 yrs) to predate logging are sometimes present on isolated ridgetops and steep, relatively inaccessible slopes. Tree species represented by old-growth individuals (with maximum age of any tree we have cored given in parentheses) include red spruce (368), yellow-poplar (310), white oak (306), chestnut oak (275), eastern red cedar (258), northern white cedar (246), eastern hemlock (220), northern red oak (180), and white pine (174).

TROJAN HORSES IN APPALACHIAN FORESTS. R. Jay Stipes, Dept. Plant Pathol., Physiol. & Weed Sci., Virginia Tech, Blacksburg, VA 24061-0331. It is now well documented that humankind and anthropogenic stresses have been responsible for the dissemination and induction of widespread tree diseases, and the resultant loss of considerable global biodiversity. The introduction of three major tree diseases ("Trojan horses") in the 20th century have exacted a tremendous toll on the survival of three major species of our indigenous tree flora in the Appalachians. Chestnut blight, introduced from the Orient at the turn of the century, destroyed about 5 billion American chestnut trees that constituted about 25% of the forest. Dutch elm disease, introduced about 1930 from Europe, has decimated millions of America's favorite landscape tree. Just recently, in the 1980s, yet a new killer, dogwood anthracnose, a suspected introduction on ornamental stock from the Orient, is now threatening the survival of the beautiful harbinger of spring, the flowering dogwood, food source for more than 30 species of birds. Will humankind ever learn? Can these phenomena be avoided as we are rapidly becoming a global village?

INSECTS OF MOSS PHLOX (*PHLOX SUBULATA*): UNEXPECTED DIVERSITY IN APPALACHIAN SHALE BARRENS. A. G. WHEELER, JR., Bur. of Plant Ind., Pa. Dept. of Agric., Harrisburg, PA 17110. Moss phlox (*P. subulata*, Polemoniaceae) is a mat-forming, suffruticose perennial that is common in mid-Appalachian shale barrens. This pioneer, xerophytic plant has been largely ignored by entomologists. Studies conducted mainly in southwestern Virginia and eastern West Virginia (1989-1994) have shown that moss phlox supports a rich insect community--one more diverse than that associated with plants of more complex architecture. The fauna includes two recently described species and at least four other new species that remain undescribed. Several of these insects also develop on the other eastern narrow-leaved phloxes of prostrate growth habit, *P. bifida* and *P. nivalis*. Insects associated with these plants are not generally found on phloxes of more erect growth, e.g., *P. divaricata*. Several of the specialist herbivores of moss phlox may be endemic to the mid-Appalachians; they are as characteristic of shale barrens as are endemic plants of these specialized communities.

Psychology

THE INFLUENCES OF CAREER COMMITMENT AND CHILD REARING ON RETENTION FOR ENLISTED WOMEN IN THE NAVY. Marsha Anderson, Janice Halecki, Andrea Berndt, Michelle Kelley, Dept. of Psychology, Old Dominion University, Norfolk, Va. This study examined the extent to which career commitment and child rearing variables influenced retention decisions early in the enlisted woman's career. The Maternal Separation Anxiety Scale (MSAS) was used to measure relations between three specific aspects of separation anxiety (Maternal Separation Anxiety, Perception of Separation Effects on the Child, and Employment-Related Separation Concerns) and retention. Results demonstrated correlations between Employment-Related Separation Concerns and retention ($r = .43$) and Maternal Separation Anxiety and retention ($r = -.32$). Future studies may wish to examine these correlations for use as predictive measures of retention among young enlisted women with children.

THE EFFECT OF COMBINATIONS OF INSULIN, GLUCOSE, AND SCOPOLAMINE ON MEMORY RETENTION OF RATS IN THE RADIAL ARM MAZE. J. Blanchard, S. Shands*, & P. Duncan, Dept. of Psych., Old Dominion Univ., Norfolk, Va. 23529. Previous research has shown that glucose is an effective agent in facilitating memory performance as well as attenuating scopolamine-induced amnesia. Insulin has also been shown to attenuate scopolamine's detrimental effects upon memory. This study was designed in order to determine how various combinations of insulin (IN), glucose (GL), and scopolamine (SC) would affect memory retention. It involved nine rats whose memory performance was assessed through a win-shift radial arm maze (RAM) task under various drug treatments. The percentage of memory errors made in the RAM task under each condition was recorded. A $2 \times 2 \times 2$ (IN X GL X SC) within-subjects design was employed. The results indicated that SC disrupted memory performance. An antagonistic interaction between GL and IN, as well as a two-way interaction between IN and SC was found. IN attenuated SC-induced amnesia but IN alone had no effect upon memory performance. GL counteracted SC's effects as well. Post-experimental blood glucose (BG) tests suggest that the drug treatments had no effect upon BG levels. The noncritical nature of BG levels in GL and IN attenuation of SC is discussed.

THE EFFECTS OF GENDER AND SOCIAL SETTING ON PEERS' PERCEPTIONS OF UNEXPLAINED SYMPTOM COMPLAINTS. Jennifer Cheavens and Barbara Winstead*, Dept. of Psych., Old Dominion Univ., Norfolk, Va. 23529. Multiple Chemical Sensitivity (MCS) is a poorly understood health problem that affects mainly women. The present study attempted to examine the effects of gender and social setting on peers' perceptions of the unexplained symptom complaints associated with MCS. It was hypothesized that symptoms of males would be perceived as physiological in nature and symptoms of females would be perceived as psychological in nature. It was also hypothesized that symptoms of characters affected in a work environment would be perceived as more physiological than those in a non-work environment. Participants read a vignette describing a character with MCS then recorded perceptions about the character on a corresponding questionnaire. Results indicated that the symptoms of male characters were rated as more psychological in nature and symptoms of female characters were rated as more physiological in nature. There was no significant difference for the work/non-work environment. Participants' willingness to help characters in the vignettes was also examined. Further research is needed to explain incongruities between the present study and previous literature.

EFFECTS OF ENTORHINAL CORTEX LESIONS ON ACTIVITY, EATING AND DRINKING. R. T. Cober, N. A. Tatar*, K. A. Freeman, C. M. Hemmert*, J. A. Olejniczak, and L. E. Jarrard. Dept. of Psychol., Washington & Lee Univ., Lexington, Va. 24450. The effects on behavior of conventional electrolytic as compared to more selective aspiration lesions of entorhinal cortex (EC) was studied using a computer-controlled system that automatically records activity, eating, and drinking in the home cage. In addition to recording when these behaviors occurred, the amount of food and water consumed each day was determined. The rats were placed in the system for 7 days before the operations, the operations were carried out, and behavior was recorded postoperatively for 13 days. Rats in the control and aspiration EC groups did not differ; however, electrolytic EC lesions resulted in increases in home-cage activity both during the day and night. Since electrolytic lesions of EC result in damage to adjacent structures (subiculum, hippocampus), the increase in activity that was found can probably be attributed to this extra-entorhinal damage.

DEPRESSION AND SIMPLE MANUAL MANIPULATION: ABSENCE OF EFFECT IN POPPING SEALED AIR CAPSULES. Joy M. Conner and James P. O'Brien, Virginia Beach Campus, Tidewater Cmnty. Col., Virginia Beach, Va. 23456. Dillon (1992) found that popping two sheets of sealed air capsules in a 5-min. period was more stress-reducing than doing nothing for a 5-min. period. To the contrary, Taylor, Purser, and Baluch (1994) found an increase in state-anxiety for subjects popping capsules for a 5-min. period compared to subjects who did nothing for 5 min., and no differences in trait-anxiety. Since depression should be as stable a personality characteristic as trait-anxiety and since it is characterized by withdrawal from activity and motor retardation, 53 subjects were administered the Beck Depression Inventory (BDI) and then had the opportunity to pop capsules as they wished for a 15 sec. period. Contrary to predictions, there was no significant inverse correlation between BDI scores and capsules popped ($r=-.148$, $p=.29$), capsule popping means were in the hypothesized direction but not significantly different ($t=1.02$, $p>.31$). For further study, it is recommended that the capsule popping task be conducted in isolation to avoid group effects.

ABSENCE OF A "SPRING BREAK EFFECT" IN ALCOHOL CONSUMPTION AMONG COMMUNITY COLLEGE STUDENTS EXCEPT FOR HEAVY DRINKERS. Sharon L. Duprey, Donna M. Henderson, and James P. O'Brien, Tidewater Community College, Va. Beach Campus, 1700 College Crescent, Virginia Beach Va. 23456. While alcohol abuse has become a notorious aspect of the annual college "Spring Break," little, if any, research has been reported on its effect, in spite of the fact that it may affect consumption surveys spuriously. Community college students ($N=46$) provided matched samples for before and after "Spring Break" consumption on four 7-day Retrospective Diary (RD) items (occasions and quantities) and two Quantity Frequencies (QF) items: one item for occasions/month (30-day QF) and one for occasions and quantities/2 weeks (14-day QF). Except for 14-day QF, all other RD and QF items fail to support the alternative hypothesis of a "Spring Break Effect" for this community college sample. On the 14-day QF, heavy drinkers (5+ drinks in at least one sitting) were 5 times more likely to increase than to decrease occasions because of "Spring Break" ($\chi^2 = 9.08$, $p < .02$, $df = 2$). Since this sample is a non-traditional college population, future research should apply the same approach to typical 4-year college students.

A NOVEL TECHNIQUE FOR ASSAYING BEHAVIORAL RESPONSIVITY OF GOLDFISH TO WATERBORNE OLFACTORY STIMULI. Kimberly A. Freeman, Emily Pfister*, & Jeanine S. Stewart*, Dept. of Psychology, Washington & Lee University, Lexington, VA 24450. Goldfish exhibit regeneration of lesioned peripheral olfactory structures within a matter of weeks (Stewart & Brunjes, Brain Res., 628:243, 1993). A question remains regarding the functional recovery which may accompany this regrowth. We have begun developing a simple behavioral assay of olfactory function in goldfish, in order to assess post-lesion recovery in these animals. In our preliminary design, goldfish ($N = 16$) were placed in an aquarium filled with tap water and allowed to acclimate to their surroundings for 5 min. After this adjustment period, 4 aliquots (approximately 0.1 cc each) of 0.2M L-glutamine (an excellent olfactory stimulus for this animal) were added to the tank at timed intervals, by expulsion of the solution from a syringe mounted inside the aquarium. Animals were observed for a total of 10 min. following the first addition of amino acid, and an experimenter recorded the amount of time the fish spent in each half (with vs. without odorant) of the aquarium. Data revealed no preference for one side of the tank vs. the other, suggesting that the paradigm in its present form is not effective for assaying olfactory function. We are currently testing modifications of this paradigm which promise to be more useful for our purposes.

PERCEPTIONS OF ANOREXIA NERVOSA: INFLUENCE OF RATER AND TARGET GENDER. Melissa Garrido, Dept. of Psychology, Old Dominion University, Norfolk, Va. 23529. This study examined differences in perceptions of targets with Anorexia Nervosa based on rater and target gender. Raters ($N = 225$) read brief descriptions of a male or female target with eating patterns similar to persons with Anorexia Nervosa, and completed a questionnaire rating targets on health, intelligence, psychological stability and vanity. Female raters rated all targets lower on health and psychological stability than male raters. Male targets were rated lower on intelligence and higher on vanity than female targets. Many raters (51%) stated they knew someone who followed diets similar to the target.

THE INFLUENCE OF PERSONALITY ON CLOTHING SELECTION. Kathleen M. Gibson and H. Barry Gillen, Dept. of Psychology, Old Dominion Univ., Norfolk, Va. 23510. This experiment, based on Eysenck's theory of extraversion, was designed to test the hypothesis that personality influences selection of clothing style, color, and pattern complexity. After completing the Eysenck Personality Inventory, female participant's clothing preferences were measured. These variables in dress included decoration, conformity, economy, comfort, and general interest in clothing; color preference and pattern complexity were also gauged. Results based on correlations and a multivariate analysis of variance indicate that extraverts are generally more interested in clothing and prefer its decorative aspects. Moreover, extraverts choose complex patterns and bright/intense colors. Conversely, introverts seek comfort and utility in clothing, prefer simple patterns, and select muted or non-intense colors.

MENTAL MODEL FORMATION AND EVOLUTION. Michael G. Grasso and Mark W. Scerbo, Dept. of Psychology, Old Dominion University, Norfolk Va. When interacting with systems or machinery, humans develop cognitive models that represent their understanding of how the system functions. These "mental models" are internal representations that provide operators with a framework that can be accessed when working with systems. The purpose of this project was to explore the initial formation and evolution of mental models. A commercial simulation program, SimCity 2000, was used as a vehicle for examining subjects' mental models. The program simulates the building, planning, designing, and governing of a city. One group of subjects served as a control group to determine the extent of existing mental models concerning city governing and development within this population. The remaining subjects reported for three 2-hour sessions in which 90 minutes were utilized for interaction with the SimCity 2000 program and 30 minutes to record their knowledge and understanding of the simulation. Assessment of the subjects' mental models was obtained by enumerating the number of charts and diagrams, major elements, declarative and operational statements, errors, and words used in their written reports at the end of each session. Contrary to expectations, there was a downward trend across all dependent measures over the three sessions. An analysis of variance showed that there was a significant reduction in the number of major elements and words used by the subjects between the first session and the remaining two sessions. This pattern of results suggests that subjects established and conveyed the majority of their mental models in the first session. In addition, it is also possible that the subjects became fatigued during the experimentation producing a reduction in their verbal descriptions.

INFLUENCE OF FAMILY NAVY TRADITIONS AND STRESSOR VARIABLES ON WOMEN'S RETENTION IN THE NAVY. Janice E. Halecki, Marsha Anderson, Andrea Berndt, Michelle Kelley. Dept. of Psychology, Old Dominion University, Norfolk, Va. The current climate of cutbacks and downsizing demands that organizations take a hard look at employee retention. This study examined effect of length of service, child care, and family issues on retention of Navy women who were custodial parents and assigned to ships. Women (N=89) with a mean age of 29 ($SD = 5.64$) and with 1 to 22 years of military service participated. One month after returning from a seven month deployment, the women completed the Maternal Separation Anxiety Scale, Family Environment Scale, a demographic questionnaire and a semi-structured interview designed to examine attitudes about Navy service and its effect on families. Years of service correlated positively ($r = .41, p <.001$) with intention to reenlist, while Maternal Separation Anxiety correlated negatively ($r = -.32$). Future research should examine how family issues affect retention particularly for the first enlistment of Navy mothers.

PREDICTING TEAM MEMBER BEHAVIOR FROM THE LEADER'S PERFORMANCE HISTORY. Bryan C. Hayes and Debra A. Major*, Dept. of Psychology, Old Dominion Univ., Norfolk, Va. 23529. In a team context, leader performance history has been shown to affect team members' attitudes. In theory, the attitudes should be predictive of team members' behaviors. A laboratory study demonstrated that team member attitudes were significantly influenced by the leader's performance history. However, team member's behaviors were neither affected by the performance history nor related to the attitudinal measures. Results are consistent with empirical evidence on the relationship of attitudinal predictors and criterion behaviors. Attitudes accurately predict overt behavior only when the attitudinal and behavioral measures correspond on specific dimensions. One important dimension is correspondence on the specific behavioral action.

MOTHERS' USE OF INFORMATIONAL AND SOCIAL RESOURCES PREDICTS PARENTING STRESS. Kelly Heiges & Jeffrey Pickens, Dept. of Psych., James Madison Univ., Harrisonburg, Va. 22807. A survey was used to assess the relationship between mothers' use of informational resources (including books and parenting classes), use of social resources (receiving help from a friend or relative), and maternal stress levels reported on the Parenting Stress Index. Sixty-three mothers completed the questionnaire; half classified as low socioeconomic status and half from a high social status group using the Hollingshead Four Factor Index of Social Status. Use of social resources was significantly correlated with overall maternal stress levels, indicating that social support can mitigate parenting stress. Those subjects that used more social resources were also less likely to report feeling restricted in their role as mothers. Higher social status mothers reported greater use of books and child care workers for childrearing advice than low social status mothers. These findings support previous research on the effectiveness of social support in alleviating parenting stress.

A FEEDBACK CONTROL SYSTEM FOR REGULATING OPERATOR ENGAGEMENT IN A SIMULATED FLIGHT ENVIRONMENT. James M. Hitt, II, Lawrence Prinzel, III, Frederick G. Freeman*, and Mark W. Scerbo*, Dept. of Psych., Old Dominion Univ., Norfolk, Va., 23529-0267. Understanding pilot error has been one of the primary issues confronting human factors and ergonomics professionals over the years. One approach to preventing human error would be to monitor the levels of workload and attention in human operators. Decremental can then be assessed and necessary safeguards can be implemented before disaster occurs. Little research has been conducted to determine the possible indices for measuring fluctuating states of attention and workload. The current study sought to validate an index using a physiological measurement (EEG). The rationale behind the research was to determine if the chosen index, $(\text{Beta})/(\text{Alpha}+\text{Theta})$, is sensitive to fluctuating states of attention under positive and negative feedback contingencies and automatic and manual modes of operation. The level of automation in the system was determined using the absolute power bands of the Alpha, Beta, and Theta waves recorded from four cortical sites (Pz, Cz, P3, P4). Participants performed a compensatory tracking task for two sixteen-minute periods. Tracking performance was measured using the RMSE from the task. Scores from the NASA-TLX mental workload scale provided a subjective workload measure after each trial. The results from the experiment indicated that the bio-cybernetic, closed loop system was sensitive to fluctuating states of attention. This was illustrated in an interaction effect found between the engagement index and the level of automation. Further validation of the system was shown by the results of the tracking task and the NASA-TLX scores. RMSE was found to be significantly lower in the negative feedback condition. Scores from the NASA-TLX showed that workload in the negative feedback condition presented moderate levels of workload. The present study demonstrates convergent validity for a bio-cybernetic system and its usefulness in achieving dynamic task allocation while on-line.

EXPERIMENTAL INVESTIGATIONS OF ODOR IMAGERY. Samuel R. Jones, J.D. Cochran*, J. Ayers*, D.G. Elmes, L. Murphy*, S. Sharp*, and D. Thomas*, Dept. of Psychol., Washington and Lee Univ., Lexington, VA 24450. In the first of two experiments, three independent groups of subjects engaged in different processing tasks prior to olfactory identification. One group saw a visual representation of an odor stimulus (e.g., a *lemon*), a second group saw the representation and also imagined its odor, and a third group did nothing prior to odor identification. Although subjects who imagined the target odors correctly identified more odors than any other subjects, the differential amount of odor priming was not appreciable. The second experiment used a within-subjects design, in which blindfolded subjects either sniffed an odorant, imagined its odor, or imagined its visual representation. After filler tasks the subjects engaged in an old/new odor recognition task. Corrected recognition was highest for old odors that were sniffed, and there was little difference in recognition for odors that were imagined or visualized. Consistent with other work, the present results provide minimal evidence for the existence of odor imagery.

EFFECTS OF PAVLOVIAN CONDITIONING ON CAFFEINE INDUCED HYPERLOCOMOTION IN THE RAT. Lisa A. Kaminski & Perry M. Duncan, Dept. of Psych., Old Dominion Univ., Norfolk, Va. 23529. This study investigated the effects of classical conditioning on caffeine-induced hyperlocomotion in rats. In the conditioning paradigm animals received a low dose (15 mg/kg) or high dose (30 mg/kg) of caffeine by IP injection immediately before placement into an activity counter. A predictive stimulus of menthol odorant was also used. Following eight days of conditioning, test trials were conducted in which rats were given IP injections of saline before activity measurement. Analysis of conditioning trials revealed that the animals showed increased locomotor activity following caffeine administration but did not show sensitization to caffeine's stimulus effects over trials. The subjects also did not demonstrate a conditioned hyperlocomotion response during test trials.

THE EFFECT OF MOOD ON ACTIVITY SELECTION AND ACTIVITY SELECTION ON MOOD: A POTENTIAL CYCLE FOR INTENSIFIED MOOD STATES. Michael L. Kohn and Raymond H. Kirby. Dept. of Psyc., Old Dominion Univ., Norfolk, Va. 23529. The effects of mood on activity selection and the effects of activity participation on mood were examined. Twenty-two subjects experienced a neutral or a negative mood induction and were then given an option to participate in either a negative or positive activity (viewing a 5 to 10-min film clip). In addition, to explore how participation in different activities affects moods, 14 subjects received a negative mood induction and were then assigned to view either a negative or a positive film clip. It was hypothesized that (1) the depressed mood group would prefer the negative over the positive film, (2) attending to a mood-congruent activity would augment the mood, and (3) attending to an incongruent activity would diminish the mood. The results revealed the opposite effect for Hypothesis 1, no significant effect for Hypothesis 2, and confirmed Hypothesis 3. Mood repair and modes of mood induction are discussed as possible explanations for the findings.

EFFECTS OF NURSING HOME VISITATION ON CHILDREN'S ATTITUDES TOWARD THE ELDERLY. Mary Carole Davis' Libre, Tidewater Cmnty. Col. and Virginia Wesleyan Col., Maria R. Hobbs, Kort Miller, Steven E. Litherland, and James P. O'Brien, Tidewater Cmnty. Col., VBC, Virginia Beach, VA. 23456. Seefeldt, et al. found more negative attitudes toward the elderly and one's own aging especially among younger elementary and pre-school children on post-test vs pre-test measures. This study evaluated 4th grade students: 26 in the experimental group who visited a nursing home monthly and 15 control 4th graders. Subjects' attitudes, as assessed by subtests of The CATE (Children's Attitudes Toward the Elderly), yielded insignificant t-tests; however, 9 of 10 semantic differential items for the old were more positively rated by experimental subjects than controls. No significant differences in prosocial peer behavior were observed in various classroom activities. These findings, contra to Seefeldt, et al., for these older subjects visiting less infirmed elderly and implications for future research are discussed.

HOW SOCIAL SUPPORT AFFECTS EMPLOYEE PERFORMANCE: AN EMPIRICAL STUDY. Curtis S. McKee, Dept. of Psychology, Radford Univ., Radford, Va. 24142. Gail H. McKee, Dept. of Business Administration and Economics, Roanoke College, Salem, Va. 24153. The impact of social support on the job performance of 156 piecework employees at a sewing plant in the southeastern U.S. was examined. Job performance was measured by supervisory ratings and average hourly piece rate earnings, which were found to be highly correlated in this study ($r=.67$, $p<.001$). Various sources of social support (e.g. one's supervisor, co-workers, and family members or friends) were also studied in order to see if the provider of social support had a differential impact on job performance. Employees perceiving more supervisory social support received higher supervisory ratings, but did not have higher average hourly piece rate earnings. An unexpected finding was that those employees perceiving little social support from co-workers outside their unit, had higher piecework earnings. This may reflect disinterest or even antagonism by the high producers toward anyone outside their unit, who either had no effect upon their work or who could potentially impede their productivity.

AN EMPIRICAL INVESTIGATION OF THE RELATIONSHIP BETWEEN JOB FRUSTRATION AND PERFORMANCE: SOME PRELIMINARY FINDINGS. Gail H. McKee, Dept. of Business Administration and Economics, Roanoke College, Salem, Va. 24153. Curtis S. McKee, Dept. of Psychology, Radford Univ., Radford, Va. 24142. This study took place in a sewing plant in the southeastern part of the United States. The sample was comprised of 155 employees, who were paid on a piecework basis. Performance was measured by an employee's 13 week average piece rate and by each employee's supervisory rating. It was found that the more frustration employees perceived, the lower was their piece rate earnings ($r = -.24$, $p<.01$) and the lower was their supervisor's rating of their performance ($r = -.18$, $p<.05$). There was no relationship found between frustration and self-reported number of repairs ($r = .05$, n.s.). Some preliminary findings on sources of frustration in an organization and expected organizational outcomes are also discussed in relationship to Spector's (1978) model of organizational frustration.

THE RELATIONSHIP BETWEEN HEALTH ISSUES AND PERSONALITY VARIABLES AS A FUNCTION OF GENDER. Richard K. Neal III, Dept of Psychology, Old Dominion University, Norfolk, Va. 23529. The present study examined relationships between personality variables and self reports of nine health related behaviors for 65 college students (male=30, female=35). Personality variables were assessed using questionnaire items from prior research. It was hypothesized that males would report less healthy behaviors (i.e., more one-night stands, more drinking, and more cigarette smoking) than would females. Results supported the hypothesis that males would report more one night stands. One night stands and drinking behaviors for males and females were moderated by levels of depression, self-esteem, and extroversion. Future research should investigate the influence of these personality variables on a wider range of health issues.

ON THE ROLE OF THE SUBICULAR COMPLEX IN PLACE LEARNING IN THE RAT. R. W. Neel, M. P. Beenhakker*, J. D. Cochran*, S. E. Dallvechia*, K. H. Richter*, and L. E. Jarrard, Dept. of Psychol., Washington & Lee Univ., Lexington, Va. 24450. Selective lesions limited to either the pre- and parasubiculum (PPS) or the complete subiculum complex (subiculum, pre- and parasubiculum) (CSC) were used to study the involvement of these areas of the brain in learning and memory in the rat. Selective lesions were made by using multiple, focal injections of ibotenic acid. Following recovery, the animals in three groups (PPS, CSC, Control) were tested for utilization of spatial information by employing different versions of the Morris water maze. The PPS group, although initially impaired in locating the platform that was hidden just below the surface of the water, were able to find the platform as well as controls by the fifth day of training. Rats in the CSC group were more impaired than either controls or the PPS group. Results of the test for memory of spatial location showed that rats in the CSC group were especially impaired. These findings will be discussed in terms of the involvement of different components of the hippocampal formation in spatial learning and memory.

SMILE RECIPROCITY IN BRIEF ENCOUNTERS: REDUCED EFFECT DUE TO FINAL EXAM PERIOD. James P. O'Brien and Sue Rooker, Tidewater Cmnty. Col., Virginia Beach, Va. 23456. Hinsz & Tomhave (1991) and Walls (1981) found somewhat more than half of subjects smiled-at returned a smile or acknowledgement. This study replicated Walls' with modifications including operational definitions of smile vs no-smile, similar appearance of male and female senders, and one venue--a 12-yard sidewalk approaching a campus library entrance. Of 100 observations of cmnty. col. students on a Friday morning preceding final exam week, over half of the subjects were completely unaware of the male and female senders, as if they were focused on getting to the library to study for exams or to complete assignments. Of those responding, the female sender was positively reciprocated four times more often than the male sender. Future research should consider interactions of gender, age, and circumstance (i.e., exam periods vs other times).

ON THE ENTORHINAL CORTEX AND PLACE LEARNING: EFFECTS OF ASPIRATION VS. ELECTROLYTIC LESIONS. J. A. Olejniczak, K. A. Freeman, C. M. Hemmert*, N. A. Tatar*, R. T. Cober, and L. E. Jarrard. Dept. of Psychol., Washington & Lee Univ., Lexington, Va. 24450. The effects of conventional electrolytic and more selective aspiration lesions of the entorhinal cortex (EC) on spatial learning were studied using two versions of the Morris water maze. Conventional electrolytic lesions impaired performance on an initial multiple-trial task (4 trials/day for 5 days, plus a probe trial) and reversal learning. More selective removal of the EC using aspiration had no effect on spatial learning. In a test of forgetting (2 trials/day with location of the platform varying over days) using 30 s and 5 min delays between the daily trials, aspiration lesioned rats performed like controls but rats with conventional EC lesions were impaired at both delays. These results will be discussed with regard to the role of the entorhinal cortex in learning and memory.

ERPS (EVENT-RELATED BRAIN POTENTIALS) IN RESPONSE TO INFLECTIONAL AND DERIVATIONAL ANOMALIES. Annamarie Paulin and Thomas P. Urbach, Dept. of Psychology, Washington and Lee Univ., Lexington, Va. 24450. Two experiments were conducted to further investigate the late positive deflection (P600) elicited in other studies of inflectional anomalies with subject/verb agreement and other morpho-syntactic violations. Experiment 1 addressed the issue of whether both inflected and derived anomalies elicit a P600. The stimuli consisted of non-anomalous sentences and sentences containing inflectional anomalies and derivational anomalies. Both types of sentence medial anomalous words elicited a significant P600 relative to the non-anomalous control. In addition, the amplitude of the P600 in the inflectional and derivational anomalies differed significantly at the posterior electrode sites. The hypothesis that this difference was due to a difference between storage-and-retrieval processes and decompositional analysis processes was investigated in Experiment 2. ERPs elicited by appropriate base forms, anomalous regularly inflected forms and anomalous irregularly inflected forms. No difference was found between the regular and irregular inflected forms, so it is unlikely that the difference in Experiment 1 is attributable to the differences in processing mechanisms noted above. An alternative explanation in terms of the extent to which the anomaly disrupts the on-line analysis is proposed.

ADAPTIVE AUTOMATION: BEHAVIORAL CORRELATES AND SYSTEM DYNAMICS OF A BIO-CYBERNETIC SYSTEM. M. Risser, L. Prinzel III, & F. Freeman*, Dept. of Psych., Old Dominion Univ., Norfolk, Va. 23529. A biocybernetic system has been developed to moderate an individual's level of arousal during varied task automation. This closed loop feedback design investigated varied levels of automation in a compensatory tracking task based upon the operator's EEG that reflected their level of engagement in the task. The experiment included 18 subjects who were run under three 16 minute trials and their EEG was continuously sampled. Each subject was run under one of three indices used as a measure of engagement ($20\beta/\alpha+\theta$, $10\beta/\alpha$, or α/θ). Task modes functioned in either manual or automatic dependent on the level of operator engagement. Automation levels varied due to positive and negative feedback conditions. Under negative feedback, the task was switched to (or maintained in) automatic mode when the index reflected increasing arousal, but was switched to (or maintained in) manual when the index was decreasing. Under positive feedback, task mode was switched to (or maintained in) automatic when the index reflected decreasing arousal, but was switched to (or maintained in) manual when the index was increasing. Therefore negative feedback (stable operation) is intended to induce optimal states of engagement through short cycles of automation as opposed to positive feedback (unstable operation). The results demonstrate that the system functioned differently dependent upon the level of automation in the task and the level of operator engagement. Both negative feedback and $20\beta/\alpha+\theta$ were each found to be the most sensitive to levels of arousal operating under this system. Furthermore, tracking performance was also found to be significantly better under these conditions. The results are discussed in terms of the system's utility to regulate changing operator engagement in flight environments.

EFFECTS OF TEACHER TOUCH CUES ON CHILDREN WITH ADHD/ED.

Kimberly W. Sebrell, & Jeffrey Pickens, Dept. of Psy., JMU, Harrisonburg, Va. 22801.

Teacher's use of touch cues in the classroom with students with ED/ADHD was investigated. It was hypothesized that students would demonstrate more optimal attention, affect, physical activity and proximity to a teacher in individual versus group contexts. Furthermore, within the individual settings it was hypothesized that teacher touch would produce more optimal attention, affect, physical activity and proximity in the students. Students and teachers were videotaped during a group reading activity and a series of one-on-one reading conditions. The results supported the hypotheses, showing that students with ADHD/ED were more attentive, showed more positive affect, showed less physical activity and were in closer physical proximity to teachers in the one-on-one than group conditions. Students responded positively to teacher touch, as evidenced by students' lowered physical activity and closer proximity to the teacher during the one-on-one conditions. The results suggested that both individualized attention, and the use of touch cues, are effective strategies for educators.

USING PROCESS DISSOCIATION AND ERPS TO INVESTIGATE IMPLICIT MEMORY.

Todd H. Stanton, Thomas P. Urbach, and David G. Elmes. Dept. of Psychology, Washington and Lee Univ., Lexington, Va. 24450. Current memory theory generally divides memory in two different types: explicit and implicit. The purity of implicit tasks, however, has been questioned, and to address this, L.L. Jacoby *et al.* (1991) developed the process dissociation procedure, which provides a theoretical framework intended to estimate the contributions of both explicit and implicit memory. Nine male and eleven female volunteers were given an implicit memory task within a process dissociation paradigm while EEG data were recorded. The behavioral results show that, as predicted, subjects were more likely to complete a word stem with a word they had already seen before. In addition, Jacoby's procedure was used to estimate the influences of explicit and implicit memory. Analysis of the event-related potentials (ERPs) elicited by the word stem found significant late positive deflections similar to effects reported in other memory tasks for those stems that were completed with previously presented words.

AIDS INFORMATION: HOW MUCH DO COLLEGE STUDENTS KNOW?

Patricia Tillman, Melissa Graul, Tiffany Graves. Dept. of Psychology, Old Dominion University, Norfolk, Va. 23529. The current study assessed the knowledge of Acquired Immune Deficiency Syndrome (AIDS) among 313 college students (ages 18-26) with a questionnaire examining general knowledge of AIDS, transmission, early warning signs, preventive measures, and sexual practices. The percentage of students with knowledge about AIDS was low: general knowledge of AIDS was 36%; AIDS transmission was 14%; and early warning signs was 7%. Students were more knowledgeable about preventive measures (40%), but reported usage and knowledge of condoms was low (25%). It appears additional AIDS education is needed.

THE EFFECT OF TASK DEMANDS AND ATTENTION ON OLFACTORY RESPONSE. Mariecken A. Verspoor, Dept. of Psych., Washington and Lee Univ., Lexington, Va. 24450. It has been shown that the response to olfactory information is inhibited when performing high-demand cognitive tasks. The left hemisphere may be an integral part in the process of inhibiting olfactory information. The right hemisphere seems to be somewhat specialized for olfactory information processing. This experiment examines the effect of task demands on the topographical distribution of the olfactory response through the use of EEG data. It was found that while cortical activity decreased in the left hemisphere when an odor was presented (versus the no odor condition) across all three task types (linguistic processing, spatial processing, and olfactory processing), the cortical activity in the right hemisphere differed according to task demands. While processing both linguistic and spatial information, cortical activity in the right hemisphere decreased when an odor was presented. When processing olfactory information, cortical activity increased with odor presentation.

Statistics

OPTIMAL DESIGNS AND RESPONSE SURFACE ANALYSIS IN THE PRESENCE OF BI-RANDOMIZATION ERROR STRUCTURES. Jennifer J. Davison, Raymond H. Myers*, Marvin Lenter*, Dept. of Statistics, Va. Tech, Blacksburg, Va. 24061-0439. Cost control, resource availability, or difficulty in performing complete randomizations may dictate the necessity to run response surface experiments in a bi-randomization format of which the split-plot design is a special case. A bi-randomization (BRD) scheme allows for certain factor levels to be applied to larger experimental units with remaining factor levels randomly applied to nested smaller units. For example, in the dual response surface approach to robust parameter design, process mean and variance models are formulated to aid in designing products to be "robust" to uncontrollable system influences, noise. In model development, noise variables are controlled in the laboratory, but due to their random nature this may be quite difficult. This suggests the need for a bi-randomization scheme in which the noise variables constitute the levels applied to the larger experimental units. For the bi-randomization situation, various error estimation procedures and analyses are explored. The efficiency/optimality of common response surface designs are examined in the presence of this error structure to determine the necessity of design modification. General recommendations for efficient designs and practical analysis methods are outlined.

ESTIMATING CHANGES IN CANCER SCREENING RATES: A COMPARISON OF METHODS. Robert E. Johnson & Christie Riles, Dept. of Mathematical Sciences, Va. Commonwealth Univ., Richmond, VA, 23284-2014. The purpose of this paper is to explore the effects of an informational intervention on the probability that an eligible patient will be screened for breast cancer. These probabilities are estimated and compared across two time periods and between two experimental groups. The objectives are approached through the context of screening for cancer amongst asymptomatic patients by a method of comparison of means and a "life testing" method. The first method uses adjustments to the variance of the means and mean differences based on a two-stage sampling design. The second method adds an adjustment for the degree of exposure to the completion of screening.

OPTIMAL ONE AND TWO-STAGE DESIGNS FOR THE LOGISTIC REGRESSION MODEL. William C. Letsinger, Raymond H. Myers, Dept. of Statistics, Va Tech, Blacksburg, VA 24061-0439. Binary response data is often modeled using the logistic regression model, a well known nonlinear model. Designing an optimal experiment for this nonlinear situation poses some problems not encountered with a linear model. Primarily, the implementation of an optimal designs requires the parameters of the model to be known. However, the model parameters are not known. Consequently the parameters must be specified prior to implementing a design. Standard one-stage optimal designs are quite sensitive to parameter misspecification and are therefore unsatisfactory in practice. A two-stage Bayesian design procedure is presented which effectively copes with poor parameter knowledge while maintaining high efficiency. Asymptotically, the two-stage design procedure is considerably more efficient than the one-stage designs when the parameters are misspecified and only slightly less efficient when the parameters are known. However, the true advantage of the two-stage procedure is most evident for small samples.

OPTIMAL CENTRAL COMPOSITE DESIGNS WITH DISPERSION EFFECTS. D'Arcy P. Mays, Dept. of Mathematical Sciences, Va. Commonwealth Univ., Richmond, Va. 23284. The central composite design (ccd) is often used to provide estimation of a second order regression model. The ccd involves a (possibly fractionated) two level factorial design, axial points, and replicated runs in the design center, and is usually used with the assumption of homogeneous variance in the design region. However, when dispersion effects exist the standard ccd may not be optimal. With a specified number of experimental runs available the goal is to find the optimal allocation of the runs to the ccd locations. Several variance structures will be considered, in conjunction with several (scaled) degrees of heterogeneity expressed in terms of variance ratios. Optimality criteria based on the determinant of the variance-covariance matrix of coefficients (D-optimality) and on the integrated prediction variance (Q-optimality) will be used. Due to constraints created by the scaled variances and variance structures, the procedure places restrictions on the choice of the axial distance. These restrictions will be analyzed, and the optimal designs will be presented for several variance structures, variance ratios, and appropriate choices of axial distance. The analysis will show that the ccd used when homogeneous variance exists is not the optimal design when dispersion effects exist.

SOME DEVELOPMENTS IN MODEL ROBUST REGRESSION. James E. Mays & Jeffrey B. Birch, Dept. of Statistics, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. In obtaining a regression fit to a set of data, ordinary least squares regression depends directly on the parametric model formulated by the researcher. If this model is incorrect, a least squares analysis may be misleading. Alternatively, nonparametric regression (kernel or local polynomial regression, for example) has no dependence on an underlying parametric model, but instead depends entirely on the distances between regressor coordinates and the prediction point of interest. This procedure avoids the necessity of a reliable model, but in using no information from the researcher, may fit to irregular patterns in the data. The proper combination of these two regression procedures can overcome their respective problems. Considered is the situation where the researcher has an idea of which model should explain the behavior of the data, but this model is not adequate throughout the entire range of the data. An extension of partial linear regression and two methods of model robust regression are discussed and compared in this context. These methods involve parametric fits to the data and nonparametric fits to either the data or residuals. The two fits are then combined in the most efficient proportions via a mixing parameter. Performance is based on bias and variance considerations.

ANALYSIS OF GROWTH CURVES UNDER AUTOREGRESSIVE COVARIANCE STRUCTURE. D.N. Naik & Shobha Prabhala, Dept. of Math. & Stat., Old Dominion Univ., Norfolk, Va. 23529. The growth curve model $Y_{i_{n_i \times p_i}} = A_{i_{n_i} \times m} \xi_{m \times k} B_{k \times p_i} + \epsilon_{i_{n_i \times p_i}}, i = 1, 2, \dots, g,$ where ξ is a vector of unknown parameters, and for the i^{th} group Y_i is observation matrix, A_i is a known matrix of rank m , B_i is a matrix of rank k_i and the rows of ϵ_i are independent each distributed as $N_{p_i}(0, \Sigma_i)$, Σ_i having an autoregressive structure. The maximum likelihood estimators (MLEs) of various parameters are obtained. Prediction of future observations is discussed. The situation where data are missing leads to the Markov covariance structure for Σ_i . The MLEs under this case are also derived.

ANALYSIS OF MULTIVARIATE REPEATED MEASUREMENTS. D.N. Naik & Shantha S. Rao, Dept. of Math. & Stat., Old Dominion Univ., Norfolk, Va. 23529. In this article we consider a set of 't' repeated measurements on 'p' variables (or characteristics) on each of the n individuals. Thus data on each individual is a $p \times t$ matrix. The n individuals themselves may be divided and randomly assigned to 'g' groups. Analysis of these data using MANOVA model is considered. The well known Satterthwaite type approximation to the distribution of a quadratic form in normal variable is extended to the distribution of a multivariate quadratic form in multivariate normal variates. The multivariate tests using this approximation are developed for testing the usual hypotheses.

MODEL-ROBUST QUANTAL REGRESSION. Quinton J. Nottingham, Department of Statistics, Virginia Tech, Blacksburg, VA 24061, & Jeffrey B. Birch, Department of Statistics, Virginia Tech, Blacksburg, VA 24061. In the analysis of quantal dose-response data, the most commonly used parametric procedure is logistic regression, commonly referred to as "logit analysis." The adequacy of the fit by the logistic regression curve is tested using the chi-square lack-of-fit test. If the lack-of-fit test is not significant, then the logistic model is assumed to be adequate and estimation of effective doses and confidence intervals on the effective doses can be made. When the tolerance distribution of the dose-response data is not known and cannot be assumed by the user, one can use nonparametric methods, such as kernel regression or local linear regression, to estimate the dose-response curve, effective doses, and confidence intervals. This research proposes another alternative to analyzing quantal dose-response data called model-robust quantal regression (MRQR). MRQR linearly combines the parametric and nonparametric predictions with the use of a mixing parameter. MRQR uses logistic regression as the parametric portion of the model and either kernel or local linear regression as the nonparametric portion of the model. Preliminary research has shown promise in that the MRQR procedure improves the fit of the dose-response curve by producing narrower confidence intervals for predictions, while providing improved precision of estimates of the effective doses with respect to the logistic regression analysis.

THE ESTIMATION OF AGE DEPENDENCE IN THE SEASONAL DEPTH DISTRIBUTION OF MUSSELS. Steven R. Rein, Dept. of Math. Sciences, Va. Commonwealth Univ., Richmond, VA 23284-2014, David Balfour*, Dept. of Biology, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061, & Leonard Smock, Dept. of Biology, Va. Commonwealth Univ., Richmond, VA 23284-2012. It is believed that the mean depth (mid-mussel depth below stream bed) of mussels varies with season. One question of biological and ecological interest is whether there are age (and thus length) differences in the depth distribution, net the seasonal effects. During each of ten months of 1994, ten 15 meter long plots were sampled from a 1.5 kilometer section of brackish stream in Southeast, Virginia. The depth, to the nearest centimeter, and length of all mussels in these 150 plots was recorded. Mussels that were on top of the stream bed were recorded as having zero depth. In whole, 251 mussels were found, with the monthly count ranging from 8 to 46. We propose to model the depth distribution as a Poisson with zeroes, where the contagion parameter and the expectation of the Poisson are each functions of date and length. Some exploratory work will be done to determine the shape of these functions, then function parameters will be estimated via maximum likelihood. Attention will be given to assessing the departure of the data from the Poisson with zeroes.

USING SIMULATED ANNEALING TO FIT PHASE-TYPE DISTRIBUTIONS. Leah C. Snediker & John A. Barnes, Dept of Mathematical Sciences, Virginia Commonwealth University, Richmond, VA 23284. There has been much research in recent years on using phase distribution in queueing modeling. Phase distributions are based on convolutions of exponential distributions and hence can be used in the building of Markovian models. Theoretically, any non-negative random variable can be approximated arbitrarily closely (non-uniquely) using phase distributions. There has been limited research on the practical matter of finding such approximations. In our research we use a Simulated Annealing approach to fitting phase distributions to other types of distributions. Unlike other approaches that only attempt to fit a few moments, our approach is to fit the distribution function itself.

ROBUST ESTIMATION OF SCALE IN THE TWO-SAMPLE MODEL. Jeffrey D. Vest and Clint W. Coakley*, Dept. of Stat., Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061-0439. In the last few years, estimators of the scale of a univariate distribution have been developed that are location-free in the sense that they do not depend on an estimate of the center of the underlying distribution. These proposed location-free estimators have generally been quite robust in terms of having a high breakdown point and can achieve a surprisingly high Gaussian efficiency. This idea has also been extended to the simple linear regression model, where typical estimators of the dispersion of the errors depend on an estimator of the regression line. The few estimators that have been developed that do not depend on a line estimator, called regression-free scale estimators, do achieve a high breakdown point but are useful mainly for data sets that have no replication at any regressor value. We propose new regression-free scale estimators that achieve a high breakdown point and are useful when the data contain replication. Additionally, the proposed estimators reduce to existing location-free estimators in the case of univariate data. Breakdown points and efficiency results are given for the special case where there are only two regressor values.

Biomedical and General Engineering

COHERENCE: A NEW METHOD OF ANALYZING MULTICHANNEL ELECTROGRAMS FOR DEFIBRILLATION RESEARCH. Lahn Fendlander, Dept. of Biomedical Eng., Va. Commonwealth Univ., Richmond, Va. 23298. Many factors have been identified which affect the outcome of a defibrillation attempt. However, defibrillation remains probabilistic in nature. We are still unable to explain the occurrence of many low-energy successes and high-energy failures. This suggests that other factors may exist. This research attempts to determine if one parameter in particular -- the electrical organization of the heart -- affects the outcome of a defibrillation attempt. A new method of quantifying the organization of the electrical activity of the heart is introduced. The method employs the coherence spectrum to analyze multichannel electrograms. Specifically, the magnitude-squared coherence function is used to compare the similarity of multiple electrograms recorded from an epicardial electrode plaque. From this analysis, a "coherence length" parameter is obtained. The coherence length parameter is a new concept and may be helpful in quantifying the electrical organization of the heart during ventricular fibrillation (VF).

ORIGINS OF THE SOPA SURFACES. William P. Harrison, Jr., Engr. Fundamentals Div., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. The SOPA surfaces introduced in 1994 created some interest in the origin and background development of these mathematical surfaces. This paper attempts to respond to those inquiries. The ideas that led to the creation of SOPA surfaces sprang principally from two main sources: (1) the formalized, graphical classification of planes in space, accompanied by measurement of their principal angles, θ_F , θ_H , and θ_P ; and, (2) the use of CAD software to manipulate plane-surfaced solids to allow such software to measure θ_F , θ_H , and θ_P values for these plane surfaces. Only planes classified as oblique present real interest, since all others produce the trivial and well-known result: $\Sigma\theta = 180^\circ$. Oblique planes, however, always result in $\Sigma\theta < 180^\circ$. Therefore, a systematic investigation of $\Sigma\theta$ values for the continuum of all oblique planes in space appeared warranted. Fortunately, double-rotation techniques developed in source (2) investigations provided a mechanism by which such a systematic investigation could be conducted, giving the SOPA surfaces.

MEASUREMENT OF RED BLOOD CELL VELOCITY AND SPATIAL DISTRIBUTION IN ARTERIOLES OF HAMSTER RETRACTOR MUSCLE USING VIDEO IMAGE ANALYSIS. Anand A. Parthasarathi*, & Roland N. Pittman, Dept. of Biomedical Engineering & Physiology, Va. Commonwealth Univ., Richmond, Va. 23298. A new technique for measuring red blood cell (RBC) velocity and spatial distribution using fluorescent video microscopy was developed. RBCs from anesthetized hamsters were labeled using fluorescein isothiocyanate (FITC) with a labeled cell fraction between 0.5 to 1.0%, so that on the average not more than two fluorescent RBCs (FRBC) should be observed at the point of measurement during a single video frame. The microscope and camera, fitted with an intensifier, were assembled to form a Ploem system with fluorescence excited through epi-illumination using objective magnifications of 20x and 50x. An external function generator was used to control the shuttering frequency of the intensifier. For velocities up to 20 mm/s a shuttering frequency of 180 Hz gave the best results; for higher velocities a shuttering frequency of 300 Hz was found to be optimal. Multiple images of a moving FRBC were obtained on a single video frame and recorded for later determination of velocity as the distance between successive FRBC images divided by the associated time interval. Calibration measurements using labeled RBCs gave values within 5% accuracy for velocities up to 10 mm/s and within 15% for velocities between 10 mm/s and 20 mm/s. Velocity profiles at the upstream and downstream sites of arterioles in hamster retractor muscle were determined. Upstream profiles were sharper than the downstream profiles even though the average value remained almost constant. The range of velocities that can be reliably measured using this technique depends on the intensity of the object, its size, and the shuttering frequency. This technique will be combined with existing video-based measurements of luminal oxyhemoglobin concentration to obtain improved estimates of convective and diffusive oxygen transport in microvessels. (Supported by NIH grant HL18292)

1995 BEST STUDENT PAPER AWARDS

AGRICULTURE, FORESTRY, AND AQUACULTURE

Kori S. Baker

Agricultural Research
Virginia State University
c/o Dr. S. Wildeus
P.O. Box 9383
Petersburg, Va 23806

Breed Differences in Breeding Soundness Examination Tests in Meat-type Male Goats

ARCHAEOLOGY

Courtney Anderson

Mary Washington College
1301 College Avenue
Fredericksburg, VA 22401

Prehistoric Archaeology at the Mulberry Island Site, Richmond County, Virginia

ASTRONOMY, MATHEMATICS, AND PHYSICS

Dustin McNulty

Physics Department
James Madison University
Harrisonburg, VA 22807

Operation and Design of the CLAS Forward Electromagnetic Calorimeter

BIOLOGY

Katherine W. Nowell

Dept. of Biology Sciences
Mary Washington College
c/o Dr. Rosemary Barra
Fredericksburg, VA 22401

The Effects of Chemotherapeutic Agents on ME-180 Cells and p53 Production

BIOMEDICAL AND GENERAL ENGINEERING

Lahn Fendelander

Biomedical Engineering Program

Virginia Commonwealth University

1030 W. Franklin Street

Apt. 21

Richmond, VA 23220

Coherence: A New Method of Analyzing Multichannel Electrograms for Defibrillation Research

BOTANY

Stephanie Roback

Dept. of Biological Sciences

Old Dominion University

c/o Dr. H. G. Marshall

Norfolk, VA 23529-0266

Appraising the Species Composition of the Diatom Genus Pseudonitzschia in the Southern Chesapeake Bay

CHEMISTRY

Rooma M. Mehta

Dept. of Chemistry

Virginia Commonwealth University

c/o Dr. R. G. Bass

Box 842006

Richmond, VA 23284-2006

Synthesis and Characterization of Polyimides Prepared via Diels-Alder Reaction Between 3,3'-(Oxydi-p-phenylene)bis(2,4,5-triphenylcyclopentadienone) and Various Bisacetylenes

COMPUTER SCIENCE

Ben Fornshell (co-recipient)

Dept. of Computer Science

Mary Washington College

6911 Quander Rd.

Alexandria, VA 22307

The Effect of Topology and Protocol Selection on Local Area Networks

Ping (Frank) Wang (co-recipient)

Dept. of Computer Science

Randolph-Macon College

c/o Dr. John Rabung

P. O. Box 5005, Ashland, VA 23005-5505

Displays vs Static Links: A Study of Static Scope Implementation in a Pascal Compiler

EDUCATION

Kenneth S. Lawwill

Dept. of Curriculum and Instruction

Virginia Polytechnic Institute and State University

Chantilly High School

4201 Stringfellow Rd., Chantilly, VA 22021

Encouraging Secondary Science Teachers to Implement a Greater Variety
of Writing by Their Students**ENVIRONMENTAL SCIENCE**

None received

GEOGRAPHY

Jennifer Ware (co-recipient)

Dept. of Geology and Geography

James Madison University

Harrisonburg, VA 22807

Land Use/Land Cover Analysis for an Area Behind the Valley Mall,
Harrisonburg, Virginia, Using Aerial Photography and Satellite Imagery
From 1966-1992

Greg Dillon (co-recipient)

Dept. of Geology and Geography

James Madison University

Harrisonburg, VA 22807

Assessing White-tailed Deer (*Odocoileus virginianus*) Population in an
Urban Park in Harrisonburg, Virginia**GEOLOGY**

Kelly K. Greaser

Dept. of Geological Sciences

Old Dominion University

c/o Dr. Francis O. L. Dudas

Norfolk, VA 23529

Oxidation State of Spinel Xenocrysts from Mole Hill, Rockingham
County, Virginia**MATERIALS SCIENCE**

Michael T. Stawowy

Materials Science and Engineering Department

Virginia Polytechnic Institute and State University

c/o Alex O. Aning, Blacksburg, VA 24061

Processing and Properties of FeW Amorphous Particle Strengthened
Metal Matrix Composites

MEDICAL SCIENCES

David W. Mullins

Dept. of Biology - Microbiology and Immunology Section

Virginia Polytechnic Institute and State University

c/o Dr. Klaus D. Elgert

2119 Dearing Hall

Blacksburg, VA 24061-0406

Taxol-mediated Changes in Fibrosarcoma-induced Macrophage Function: Down Regulation of Immunosuppression and Enhanced Antitumor Activities

NATURAL HISTORY AND BIODIVERSITY

Kevin L. S. Drury

Dept. of Fisheries and Wildlife Sciences

Virginia Polytechnic Institute and State University

Blacksburg, VA 24061-0321

Reliability and Efficiency of Morphological Indices of Salamander Nutritional Condition

PSYCHOLOGY

Todd H. Stanton

Dept. of Psychology

Washington and Lee University

Lexington, VA 24450

Using Process Dissociation and Event-related Potentials for Understanding Procedural Memory

STATISTICS

Jeffrey D. Vest

Dept. of Statistics

Virginia Polytechnic Institute and State University

c/o Dr. Clint W. Coakley

Hutcheson Hall

Blacksburg, VA 24061-0439

Robust Estimation of Scale in the Two-Sample Model

HONORABLE MENTIONS**AGRICULTURE, FORESTRY, AND AQUACULTURE**

C. H. Aardema

Dept. of Dairy Science

Virginia Polytechnic Institute and State University

c/o Dr. F. C. Gwazdauskas

Blacksburg, VA 24061

Effects of Variation in Milking Method, Teat Measurements, and Day of Lactation on Sow Milk Composition and Yield

CHEMISTRY

Robert H. Williams

Dept. of Chemistry

James Madison University

c/o Dr. Frank A. Palocsay

Harrisonburg, VA 22807

A Computer Interface to Predict and Compare Infrared Spectra

Charles C. Chusuei

Chemistry Department

George Mason University

c/o Dr. John A. Schreibers

Fairfax, VA 22030

A Metal Deactivator Additive Adsorbed on 304 Stainless Steel

ENVIRONMENTAL SCIENCE

None received

GEOLOGY

Michael T. Coffey

Dept. of Geology and Geography

James Madison University

c/o Dr. W. Cullen Sherwood

Harrisonburg, VA 22807

Use of the Direct Shear Device as an Aid to the Study of Mohr's Circles

MATERIALS SCIENCE

Lysle Montes

Materials Science and Engineering Department

University of Virginia

c/o Dr. Glenn Stoner

Charlottesville, VA 22903-2442

Structure and Properties of Hydrotalcite Coatings on Aluminum

Ravi Vancheeswaran

Mechanical Engineering Department

University of Virginia

c/o Dr. Haydn Wadley

Charlottesville, VA 22903

Simulation and Path Planning for the Consolidation of MMC Composites

NATURAL HISTORY AND BIODIVERSITY

Jason E. Bond

Department of Biology

Virginia Polytechnic Institute and State University

Blacksburg, VA 24061-0406

Systematics of the Spider Genera Mallos and Mexitilia (Araneae: Dictynidae)

Thomas P. Kuhar

Dept. of Entomology

Virginia Polytechnic Institute and State University

Blacksburg, VA 24061-0319

Field Studies on the Sex Ratio and Sexual Dimorphism of Western Corn Rootworm

PSYCHOLOGY

Lisa Kaminski

Dept. of Psychology

Old Dominion University

c/o Dr. Perry Duncan

Norfolk, VA 23529

Pavlovian Conditioning of Caffeine-induced Hyperlocomotion in Rats

Kathleen Gibson

Dept. of Psychology

Old Dominion University

c/o Dr. Perry M. Duncan

Norfolk, VA 23529

The Influence of Personality on Clothing Selection

STATISTICS

Jennifer Davison Letsinger

Dept. of Statistics

Virginia Polytechnic Institute and State University

c/o Dr. Marvin Lentner

Hutcheson Hall, Blacksburg, VA 24061-0439

Optimal Designs and Response Surface Analysis in the Presence of Bi-Randomization Error Structures

VIRGINIA JUNIOR ACADEMY OF SCIENCE AWARDS

AGRICULTURAL AND ANIMAL SCIENCE

- Honorable Mention: Ellen J. Dehaven
Southwest Virginia Governor's School.
- Honorable Mention: Pamela M. Morse
Southwest Virginia Governor's School
- Honorable Mention: David M. Mrazik
Ferguson High School
- Third Place: Brian M. Green
Yorktown High School
- Second Place: Adrianna N. Hancock
Chickahominy Middle School
- First Place: Erin N. Farmer
Atlee High School

ANIMAL BEHAVIOR (ETHOLOGY) 'A'

- Honorable Mention: Jonathan S. Cook
Tuckahoe Middle School
- Honorable Mention: Corinne E. Dame
Gloucester High School
- Honorable Mention: Shane M. Kigin
Thomas Jefferson Middle School
- Third Place: Kimberly A. Kalmes
J.R. Tucker High School
- Second Place: Heather B. Green
Williamsburg Middle School
- First Place: Mitchell N. Foos
Gloucester High School

ANIMAL BEHAVIOR (ETHOLOGY) 'B'

- Honorable Mention: Jessica D. Perdue
Southwest Virginia Governor's School
- Honorable Mention: Jason T. Radgowski
Central Virginia Governor's School
- Honorable Mention: Joseph E. Rupp
Thompson Middle School
- Third Place: Amy L. Lyons
Southwest Virginia Governor's School
- Second Place: Peter N. Taylor
Richmond Community High School
- First Place: Adrien K. Strickland
Thomas Jefferson High School for Science and Technology

BOTANY 'A'

- Honorable Mention: Cynthia K. Bechter
Goochland High School
- Honorable Mention: Sophia A. Esterman
Washington-Lee High School
- Honorable Mention: Julia D. Goldman
Poquoson Middle School
- Third Place: Mandi G. Bock
Gildersleeve Middle School
- Second Place: Lindsay D. Austin
Chickahominy Middle School
- First Place: Kari P. Footland
Wakefield High School

BOTANY 'B'

- Honorable Mention: Sarah Hatter
Wakefield High School
- Honorable Mention: Irena R. Hollowell
Yorktown High School
- Honorable Mention: Grace Lasker
Cave Spring High School
- Third Place: Liem T. Ha
Wakefield High School
- Second Place: Michael G. Kolejka
Roanoke Valley Governor's School
- First Place: Arun B. Jesudian
The Collegiate Schools

BOTANY 'C'

- Honorable Mention: Rachael C. Perrott
Cave Spring High School
- Honorable Mention: Janice E. Pour
Atlee High School
- Honorable Mention: Richard R. Spady
Isle of Wight Academy
- Third Place: Joseph D. Schwartz
Bishop O'Connell High School
- Second Place: John S. Will
Wakefield High School
- First Place: Meredith A. Meyer
Washington-Lee High School

CHEMISTRY 'A'

- Honorable Mention: Mary L. Bragg
Tuckahoe Middle School
- Honorable Mention: Rebecca A. Brooks
Gildersleeve Middle School
- Honorable Mention: Erin E. Gore
Ferguson High School
- Third Place: Matthew C. Crim
Chickahominy Middle School
- Second Place: Robert A. Amar
Thomas Jefferson High School for Science and Technology
- First Place: Deepa Channaiah
Roanoke Valley Governor's School

CHEMISTRY 'B'

- Honorable Mention: Cassie E. Hunter
Tuckahoe Middle School
- Honorable Mention: Michael B. Marean
Yorktown High School
- Third Place: Lori M. Lyons
Auburn High School
- Second Place: Nicholas J. Maniscalco
Atlee High School
- First Place: Stephen F. McIrvin
Thomas Jefferson High School for Science and Technology

CHEMISTRY 'C'

- Honorable Mention: Tyler L. St.Clair
Poquoson Middle School
- Honorable Mention: Clinton R. Stone, II
Fieldale-Collinsville High School
- Honorable Mention: Ronald S. Taylor, Jr.
Patrick Henry High School
- Third Place: Genevieve Parente
Bishop O'Connell High School
- Second Place: Benjamine A. Turek
Thomas Jefferson High School for Science and Technology
- First Place: Josephine Nguyen
Thomas Jefferson High School for Science and Technology

COMPUTER SCIENCE

- Honorable Mention: Timothy S. Goodman
Swanson Middle School

Honorable Mention:	Jeremy L. Williams William Fleming High School
Third Place:	Shelton R. Weatherford Tuckahoe Middle School
Second Place:	Cyrus A. Dolph, V Norfolk Academy
First Place:	Brian D. Sutton William Byrd High School

CONSUMER SCIENCE 'A'

Honorable Mention:	Elizabeth M. Brammer Roanoke Valley Governor's School
Honorable Mention:	Ann M. Bruce Chickahominy Middle School
Honorable Mention:	Leslie B. Dubeck Williamsburg Middle School
Third Place:	Nanda Channaiah Roanoke Valley Governor's School
Second Place:	Joseph C. Blankinship James River High School
First Place:	Susan G. Eakin Prince George High School

CONSUMER SCIENCE 'B'

Honorable Mention:	Catherine R. Graham Tuckahoe Middle School
Honorable Mention:	Ellen Jenkins Gunston Middle School
Honorable Mention:	Laura M. Liberante Patrick Henry High School
Third Place:	Sallie B. Higgins Tuckahoe Middle School
Second Place:	Jaime L. Moore Atlee High School
First Place:	Cory O. McGill Atlee High School

CONSUMER SCIENCE 'C'

Honorable Mention:	Katie E. Sanderson Poquoson Middle School
Honorable Mention:	Kristina N. St.Germain Tuckahoe Middle School
Honorable Mention:	Kevin P. Wilson Tuckahoe Middle School

Third Place:	Alison E. Sharpe H.B. Woodlawn
Second Place:	Sarah H. Taylor Tuckahoe Middle School
First Place:	Sarah D. Wray Roanoke Valley Governor's School

EARTH AND SPACE SCIENCE

Honorable Mention:	West M. Ailsworth B.T. Washington Middle School
Honorable Mention:	Alexander N. Pyke Yorktown High School
Honorable Mention:	Rachel N. Thessin Williamsburg Middle School
Third Place:	Christina Q. Sherman Lloyd C. Bird High School
Second Place:	Heather M. Smith Gloucester High School
First Place:	Catherine R. Airey Roanoke Valley Governor's School

ENGINEERING

Honorable Mention:	Craig P. Davis Bishop O'Connell High School
Honorable Mention:	Debra T. Kurshan Roanoke Valley Governor's School
Honorable Mention:	Aleesa R. Parde Wakefield High School
Third Place:	Phillip B. Northam Smithfield High School
Second Place:	Michael S. Amirkhanian Tuckahoe Middle School
First Place:	Jason N. Daugherty Gloucester High School

ENVIRONMENTAL SCIENCE 'A'

Honorable Mention:	Kimberly B. Beckerdite Menchville High School
Honorable Mention:	Amy M. Bowman Roanoke Valley Governor's School
Honorable Mention:	Ann C. Bruner Lloyd C. Bird High School
Third Place:	Rachel E. Bowers Wakefield High School

Second Place: Brad W. Butcher
Menchville High School
First Place: David A. Bray
T.C. Williams High School

ENVIRONMENTAL SCIENCE 'B'

Honorable Mention: Vassiliki I. Farmakis
Roanoke Valley Governor's School
Honorable Mention: Jennifer L. Frazier
Fieldale-Collinsville High School
Honorable Mention: Cynara N. Groover
Gloucester High School
Third Place: Melinda D. Foulke
Fieldale-Collinsville High School
Second Place: Eleanor L. Eyster
Central Virginia Governor's School
First Place: Rosalind A. Doty
Roanoke Valley Governor's School

ENVIRONMENTAL SCIENCE 'C'

Honorable Mention: Douglas F. Hobbs
Atlee High School
Honorable Mention: Laura R. Kornylak
Clover Hill High School
Honorable Mention: Mary-Ellen W. Lahy
Tuckahoe Middle School
Third Place: Julie D. Keller
Roanoke Valley Governor's School
Second Place: John L. Koontz
Bishop O'Connell High School
First Place: Jason M. Los
Gloucester High School

ENVIRONMENTAL SCIENCE 'D'

Honorable Mention: Yvonne M. Mowery
Tuckahoe Middle School
Honorable Mention: Diameng Pa
Wakefield High School
Honorable Mention: Jenny L. Porter
Southwest Virginia Governor's School
Third Place: Elizabeth J. Rowe
Thomas Jefferson High School for Science and Technology
Second Place: Elaine M. Sapp
Roanoke Valley Governor's School

First Place: Alan P. Moore
Gloucester High School

ENVIRONMENTAL SCIENCE 'E'

Honorable Mention: Amol K. Tripathi
Tuckahoe Middle School

Honorable Mention: Boyden D. Williams
Norfolk Academy

Honorable Mention: Charlotte T. Young
Washington-Lee High School

Third Place: Erin M. Walsh
H.B. Woodlawn

Second Place: Sarah M. Smith
Yorktown High School

First Place: Sarah E. Wilson
Southwest Virginia Governor's School

GENETICS AND CELLULAR BIOLOGY

Third Place: Diana F. Davis
Bishop O'Connell High School

Second Place: Paul G. Thomas
Thomas Jefferson High School for Science and Technology

First Place: Jill E. Williams
Southwest Virginia Governor's School

MATHEMATICS AND STATISTICS

Honorable Mention: Sarah E. Burke
Governor's School for Government & International Studies

Honorable Mention: Seth M. Wood
Roanoke Valley Governor's School

Honorable Mention: Robert J. Zalkind
Washington-Lee High School

Third Place: Puneet K. Sapra
Woodberry Forest School

Second Place: Stephen P. Poolos
Woodberry Forest School

First Place: Brian D. Crandall
H.B. Woodlawn

MEDICINE AND HEALTH 'A'

Honorable Mention: Ruby Z. Afram
Washington-Lee High School

Honorable Mention: Laura A. Hartman
Washington-Lee High School

Honorable Mention:	Megan H. Mann James River High School
Third Place:	Alicia G. Hollis Norfolk Academy
Second Place:	Yasmin D. Jilla Roanoke Valley Governor's School
First Place:	Tom L. Harmon Chickahominy Middle School

MEDICINE AND HEALTH 'B'

Honorable Mention:	James R. Sagar Williamsburg Middle School
Honorable Mention:	Taharee A. Webb Roanoke Valley Governor's School
Third Place:	David M. Shomaker Gonzaga College High School
Second Place:	M. Matthew sholley James River High School
First Place:	Leah B. Stewart Thomas Jefferson High School for Science and Technology

MICROBIOLOGY 'A'

Honorable Mention:	Rangina Hamidi Wakefield High School
Honorable Mention:	Nayeema Hoq Wakefield High School
Honorable Mention:	Paula R. Katz Roanoke Valley Governor's School
Third Place:	Maryanne R. Kiley Gloucester High School
Second Place:	Christie-Sue Decker J.R. Tucker High School
First Place:	Christopher F. Batten Phoebus High School

MICROBIOLOGY 'B'

Honorable Mention:	Xung Nham Thomas Jefferson Middle School
Honorable Mention:	Stephanie Ogilvie Cave Spring High School
Honorable Mention:	Dorian J. Zoumplis Warwick High School
Third Place:	Charles D. Robinson Southwest Virginia Governor's School

Second Place: Rebecca A. Yurek
Wakefield High School
First Place: Clay L. Sellers
Broadway High School

PHYSICS 'A'

Honorable Mention:	Michael W. Beachey Cave Spring High School
Honorable Mention:	Erin L. Douglass Tuckahoe Middle School
Honorable Mention:	John P. Dulka Yorktown High School
Third Place:	Nathan K. Brown Southwest Virginia Governor's School
Second Place:	Allen M. Clyborne Chickahominy Middle School
First Place:	Joanne M. Cunningham Chickahominy Middle School

PHYSICS 'B'

Honorable Mention:	Jonathan C. Meier J.R. Tucker High School
Honorable Mention:	James L. Miller, III Gloucester High School
Honorable Mention:	George F. Nolde Tuckahoe Middle School
Third Place:	Arthur E. Koski-Karell H.B. Woodlawn
Second Place:	Daniel M. Langley Central Virginia Governor's School
First Place:	Bryn S. Karaus Washington-Lee High School

PHYSICS 'C'

Honorable Mention:	June M. Pearson Atlee High School
Honorable Mention:	Ryan J. Westcott Chickahominy Middle School
Honorable Mention:	Catherine A. Ziegler Bishop O'Connell High School
Third Place:	Sharon L. Sadler Liberty Middle School
Second Place:	Jessica L. Ross Williamsburg Middle School

First Place: Isaac T. Yonemoto
H.B. Woodlawn

PSYCHOLOGY - GENERAL

Honorable Mention: Christina M. Carneal
J.R. Tucker High School

Honorable Mention: Marni R. Fogelson
Tuckahoe Middle School

Honorable Mention: Garrett L. Weinberg
Norfolk Academy

Third Place: Jessica M. Drummond
Williamsburg Middle School

Second Place: Daniel A. Wolf
J.R. Tucker High School

First Place: Andrew J. Glass
Lloyd C. Bird High School

PSYCHOLOGY - LEARNING & PERCEPTION 'A'

Honorable Mention: Sarah L. Bradley
Gildersleeve Middle School

Honorable Mention: Ian S. Drummond
Yorktown High School

Honorable Mention: Daniel E. Glaze
Richmond Community High School

Third Place: Toler F. Cross
Atlee High School

Second Place: Annette K. Hertwig
Washington-Lee High School

First Place: Emily E. Allen
Central Virginia Governor's School

PSYCHOLOGY - LEARNING & PERCEPTION 'B'

Honorable Mention: Christina R. Majer
Maury High School

Honorable Mention: Freida T
Richmond Community High School

Honorable Mention: Amie Weisberg
Magnet School for Science and Health Professions

Third Place: Kristen M. Varmette
Lloyd C. Bird High School

Second Place: Ashley J. McDonald
Central Virginia Governor's School

First Place: Katherine R. Saul
Yorktown High School

PSYCHOLOGY - SOCIAL

- Honorable Mention: Jaime M. Dowdy
James River High School
- Honorable Mention: David A. Ornan
Central Virginia Governor's School
- Honorable Mention: Stepehn M. Stec
Roanoke Valley Governor's School
- Third Place: Courtney L. Peek
Southwest Virginia Governor's School
- Second Place: Aubrey L. Betts
Central Virginia Governor's School
- First Place: Sara E. Hull
Clover Hill High School

ZOOLOGY

- Honorable Mention: Bridget Kuczkowski
Bishop O'Connell High School
- Honorable Mention: Melinda K. Martin
Southwest Virginia Governor's School
- Honorable Mention: Debra G. Masters
Cave Spring High School
- Third Place: Virginia R. Ebbett
Roanoke Valley Governor's School
- Second Place: Keith B. Battocchi
Washington-Lee High School
- First Place: Pascal R. Deboeck
Bishop O'Connell High School

MULTIPLE AUTHORED PAPERS

- Honorable Mention: Roxana R. Garcia, Kim Trang
Wakefield High School
- Honorable Mention: Cary M. Jones, Adrienne E. Wenger
Maury High School
- Honorable Mention: Kathryn A. Taylor, Kevin S. Flynn,
Evan B. Garber
Central Shenandoah Valley Governor's School
- Third Place: May S. Tham, Hanh T. Nguyen
Wakefield High School.
- Second Place: Noraine A. Buttar, Katrina N. Harpe
Wakefield High School
- First Place: Jesse J. Gatchalian, Jacob A. Lansing
Cong (Kevin) L. Ly
Wakefield High School.

SPECIAL AWARDS

Botany Section Award, given by the Botany Section of the VAS, to the best paper on a botanical subject. (\$50.00)

Arun B. Jesudian
The Collegiate Schools

VJAS Neuroscience Awards supported by the Auxiliary of the Virginia Neurological Society are given to three outstanding papers in the field of neuroscience. (\$50.00 each).

Alan P. Moore
Gloucester High School

Sarah M. Smith
Yorktown High School

Stephanie A. Stauffer
Washington-Lee High School

Mathematics Award for the paper that evidences the most significant contribution in the field of Mathematics. (\$50.00)

Brian D. Crandall
H.B. Woodlawn

Smith Shadomy Infectious Disease Award in honor and memory of Dr. Smith Shadomy given by the Virginia Chapter of the National Foundation of Infectious Diseases. (\$50.00)

Maryanne R. Kiley
Gloucester High School

Roscoe Hughes Award for the best paper in the field of Genetics. (\$50.00)

Paul G. Thomas
Thomas Jefferson High School for Science and Technology

Rodney C. Berry Chemistry Award for the paper that evidences the most significant contribution in the field of chemistry.(\$50.00)

Deepa Channaiah
Roanoke Valley Governor's School

The Dr. and Mrs. Preston H. Leake Award in Applied Chemistry (\$90.00 in 1995 and 1996 and then will increase to \$200.00 in 1997) will be given to the author of a research paper which best exemplifies how chemicals, chemical principles, or chemistry have been used, are used, or might be used to enhance or even to save life.

Honorable Mention: Adrianna Hancock
Chickahominy Middle School

Winner: Brad W. Butcher
Menchville High School

Russell J. Rowlett Award for the Best Research Paper of the Year.(\$50.00)

Alan P. Moore
Gloucester High School

The Virginia Psychological Foundation Meritorious Research Awards recognize outstanding presentations of research in the various fields of psychology. Each award includes a prize of \$100.00.

Andrew J. Glass
Lloyd C. Bird High School

Emily E. Allen
Central Virginia Governor's School

Katherine Saul
Yorktown High School

Sara Hull
Clover Hill High School

Virginia Sea Grant College Program Award is given by the Virginia Sea Grant College Program for outstanding marine or coastal research. (\$100.00)

Maryanne R. Kiley
Gloucester High School

American Cancer Society Award - This award is to recognize outstanding science papers related to cancer research. A certificate to each and to 1st place - \$500, 2nd place \$300, 3rd place \$125, and honorable mention \$75. There will be a ribbon with a pin for each winner. These awards are provided by the American Cancer Society (Virginia Division), Public Education Committee.

Honorable Mention: Amol K. Tripathi
Tuckahoe Middle School

Third Place: Paul G. Thomas
Thomas Jefferson High School for Science and Technology

Second Place: Yasmin D. Jilla
Roanoke Valley Governor's School

First Place: Grace Lasker
Cave Spring High School

The Gamma Sigma Delta Award (Agriculture). Presented by the VPI & SU Chapter of the Honor Society of Agriculture. This award of \$100 is presented in recognition of excellence in research dealing with application of new technologies and/or concepts in agriculture forestry, or veterinary medicine.

Adrianna N. Hancock
Chickahominy Middle School

W. W. Berry Award. This award is given by VA Power in honor of Mr. W. W. Berry who was a past Chairman of the Board of VA Power. This award of a \$500.00 Savings Bond will be presented to the best engineering paper.

Jason N. Daugherty
Gloucester High School

The Joyce K. Peterson Award is presented for the outstanding paper by a middle school student. It is presented in honor of Mrs. Joyce K. Peterson who has been an outstanding teacher in the Arlington County Schools.

Adrianna Hancock
Chickahominy Middle School

Trip to AJAS - AAAS Meeting for two students and two alternates for presenting outstanding papers. The 1996 meeting will be held in February in Atlanta.

- Winner: Adrien Strickland
Thomas Jefferson High School for Science and Technology
- Winner: Arun B. Jesudian
The Collegiate Schools
- Aternate: E. Nicole Farmer
Atlee High School
- Alternate: Jesse J. Gatchalian
Wakefield High School
- Alternate: Jacob Lansing
Wakefield High School
- Alternate: Con (Kevin) Ly
Wakefield High School

Honorary Membership - AAAS .

Timothy E. Brown
Governor's School for Government & International Studies.

Honorary Membership - VAS given to two students.

Clay Sellers
Broadway High School

David S. Zucker
H.B. Woodlawn

E.C.L. Miller Club Award to the VJAS club having the most outstanding program for the year.(\$50.00)

Ferguson High School

Bethel High School Scholarship. This \$1,000 Scholarship Award comes from the interest earned from a \$10,000 endowment contributed by the students of Bethel High School, Hampton, Va., over a two year period. Accompanying this scholarship is a rotating plaque to be displayed in the student's school for the next year. This award is based on both the students presentation and paper.

Adrien Strickland

Thomas Jefferson High School for Science and Technology

Frances and Sydney Lewis Environmental Scholarship: A \$13,000 scholarship (\$3,250 per year for four years) for the best effort by a student grades 9 to 12 in the field of environmental science. This scholarship is in the name of Frances and Sydney Lewis and is given by the Virginia Environmental Endowment

Alan P. Moore

Gloucester High School

VAS Science Teacher Award given to an outstanding science teacher.(\$100.00)

Michael Zito

Yorktown High School

Carolyn Smith

Gloucester High School

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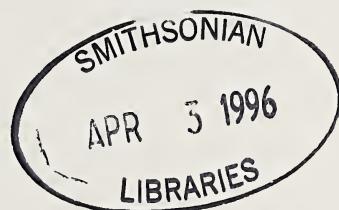
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Enumeration to 10^{14} of the Twin Primes and Brun's Constant

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ABSTRACT

The count $\pi_2(x)$ of the number of twin prime pairs $\leq x$, as well as the count $\pi(x)$ of the number of primes $\leq x$, was tabulated by means of a computer search for values of x up to 10^{14} , at intervals of 10^9 . The floating point sum of the reciprocals was also calculated, resulting in an improved estimate for Brun's constant of 1.90216 05778 with a standard deviation of $\pm 2.1 \times 10^{-9}$. An algorithm for estimating the standard deviation of such calculations is described. In the course of the computation a flaw was discovered in the hardware divider of the floating point unit of Intel Corporation's Pentium microprocessor.

Mathematical Subject Classifications (1991 MSC Series)

Primary: 11A41.

Secondary: 11-04, 11N36, 11Y60, 11Y70, 11Y35, 68M15.

Key words :Twin primes, Brun's constant, primes, Pentium flaw, computer errors.

INTRODUCTION

The set $\{(3, 5), (5, 7), (11, 13), \dots\}$ of twin prime pairs $(q, q+2)$ has been studied by Brun (1919), Hardy and Littlewood (1922), Selmer (1942), Fröberg (1961), Weintraub (1973), Bohman (1973), Shanks and Wrench (1974), and Brent (1975, 1976). Currently M. Kutrib and J. Richstein (1995) are completing a study similar to the present one.

Although it is still not known if the set is infinite, Brun (1919) proved that in any case the sum of the reciprocals

$$(1) \quad B = \left(\frac{1}{3} + \frac{1}{5} \right) + \left(\frac{1}{5} + \frac{1}{7} \right) + \left(\frac{1}{11} + \frac{1}{13} \right) + \left(\frac{1}{17} + \frac{1}{19} \right) + \dots$$

is convergent, in contrast to the divergent sum of the reciprocals of the individual primes; thus B is known as Brun's constant. Also unlike the individual primes, no indirect method is known for enumerating the twins; my investigation, like the others, simply sieves the individual primes to the desired upper bound, then checks directly for the twin pairs among them. The "Prime k-tuples conjecture," formulated by Hardy and Littlewood (1922), has as a corollary the following asymptotic formula for the count of twin primes:

$$(2) \quad \pi_2(x) \sim L_2(x) = 2c_2 \int_2^x \frac{dx}{(\ln x)^2}$$

where $\pi_2(x)$ is the number of twin prime pairs $(q, q+2)$ such that $q \leq x$, and c_2 is the "twin-primes constant,"

$$(3) \quad c_2 = 0.66016 18158 46869 57392 78121 \dots,$$

computed to 42D by J. W. Wrench (1961). See Riesel (1994, pp. 60-68) for a discussion of (2), often styled the "Hardy-Littlewood approximation," and (3).

Although (1) is convergent, the partial sums approach the limit with agonizing slowness. However, assuming the Hardy-Littlewood approximation (2), an accurate estimate can easily be derived (Fröberg, 1961) for the remainder term, producing a result which converges to the same limit much more rapidly:

$$(4) \quad B^*(x) = B(x) + \frac{4c_2}{\ln x},$$

where $B^*(x)$ is the accelerated approximation to Brun's constant and $B(x)$ is the partial sum of the reciprocals of the twins:

$$(5) \quad B(x) = \sum_{q \leq x} \left(\frac{1}{q} + \frac{1}{q+2} \right).$$

Furthermore, Brent (1975) conjectures a corresponding standard deviation of

$$(6) \quad \sigma_B(x) = \frac{\sqrt{8c_2}}{\sqrt{x} \ln(x)}$$

for the estimates of B from $B^*(x)$.

Brent (1975, 1976) extended the previous enumerations of the twins, and their reciprocal sums, to 10^{11} ; his resulting estimate for Brun's constant was $1.90216054 \pm 5 \times 10^{-7}$. To improve on this result, the author has extended these calculations three orders of magnitude, to an upper bound of 10^{14} .

COMPUTATIONAL TECHNIQUE; THE PENTIUM FLAW

The calculations were carried out exclusively on personal computers powered by Intel x86 CPUs, a mixture of 486DX-33 and Pentium systems. The operating environment was Microsoft's DOS and Windows 3.x with Win32s support added. The code was written in C, using the Windows 3.x and Win32s APIs, and compiled using Borland C++ 4.02. The computational power of the individual units was enhanced by distributing the calculations independently and asynchronously across multiple systems---five 486DX-33s early on, eventually expanding to more than a dozen Pentium systems.

The most critical section of the code lies in the procedures which sieve large blocks of integers (typically twenty million, though block size is adjusted to available physical system memory) for primes. A variation of the sieve of Eratosthenes is used, with a number of tricks added to improve speed. One array holds the base primes (those $< x^{1/2}$) used as trial divisors; actually, it contains the differences between successive primes, which require less storage (one byte for each prime $< 4.36 \times 10^8$, or $< 3.04 \times 10^{11}$ if half the difference is stored; see Brent (1973, p. 961) and Riesel (1994, p. 80)) and from which successive base primes are reconstructed by integer addition. The second array, usually much larger, has one byte corresponding to each odd integer in the block to be sieved; the byte is set to 1 for primes and zero for composites. The base primes are read in at startup from a disk file, which uses bit encoding (mod 30) to store primality information for 30 numbers per byte (bit encoding proved inefficient for the arrays in memory, due primarily to the absence in Intel x86 processors of any native mode or instructions supporting bit-based memory addressing).

The cumulative effect of evolutionary optimization illustrates the incredible power residing within current personal computers. Throughput was initially about 1.7×10^8 integers per day on a 386/387; current versions do about 10^{11} per day on modestly equipped Pentiums. This compares quite favorably with the throughput of 6.6×10^{11} per day implied by Young and Potler (1989), employing a Cray-2 on a similar problem which required no floating point arithmetic. The biggest speed boosts came from the moves to 16-bit and 32-bit Windows, the first allowing access to all of extended memory for the arrays of primes, the second eliminating segment arithmetic.

At first calculations were performed in runs of 10^{11} per machine; more recently, in runs of 10^{12} . Output was dumped to a binary disk file at intervals of 10^9 ; at the end of a run, a copy of the output file was appended to a master output file on my home system. A viewer code was written to allow analysis of the output.

Error detection and prevention was a major consideration from the outset, particularly since personal computers do not have the reputation for reliability enjoyed by workstations, mainframes, and supercomputers. A count of primes was maintained, and compared with published values (Riesel, 1994, pp. 380-383) of $\pi(x)$ at intervals. Values of $\pi_2(x)$ and the partial sums $B(x)$ of the reciprocals were compared with those obtained by Brent (1975, 1976) to 10^{11} . The reciprocal sums were computed by two independent methods. One used the IEEE floating point arithmetic native to the Intel numeric coprocessors, with a 64-bit normalized mantissa (extended precision, or long double data type, giving 19S); the other calculated the reciprocals and sums using a modification of an ultra-precision integer arithmetic package graciously donated to the public domain by A. Lenstra (1991), and as implemented produced 53D (initially 26D).

The reliance on floating point arithmetic was even more pervasive than it would appear, since the magnitude of the integers being investigated exceeded the capacity of the 32-bit registers native to the Intel processors. Thus integers exceeding $2^{32} - 1$ had to be represented as long double floating point values, with care required to guard against any associated rounding or truncation errors.

Naturally, many errors were encountered during early development, the result of logical flaws in the algorithms and code. Once these were eliminated, the calculations proceeded smoothly. Suddenly, after a group of runs was assembled and analyzed on 13 June 1994, a discrepancy appeared: the count of primes $< 2 \times 10^{13}$ was incorrect. In the process of attempting to eliminate this error (and at the same time port the code to 32-bit Windows), it was discovered that bugs in the Borland compiler were also producing erroneous results (due to incorrect rounding of quotients) in the ultra-precision sums. Not until 10 September 1994 was a ported version of the code produced with all known sources of error eliminated.

Ever more cautious (paranoid?), this time I restarted the entire calculation from zero and performed each run (of size 10^{12}) in duplicate on two machines. The first run of the first 10^{12} was performed on the only Pentium in the group; it had been added to the mix the previous March. The duplicate run was completed on my wife's 486DX-33 on 4 October 1994. It was immediately clear that their ultra-precision reciprocal sums differed. Using binary search, the difference was soon isolated to the results for the twin pair 824633702442 ± 1 , for which not only the

ultra-precision results differed, but even the floating point reciprocals returned from the CPU were in error. Several days were then spent looking for the culprit; compiler error, memory error, system bus, etc. By 19 October 1994 I was all but certain the error was within the floating point hardware unit of the Pentium CPU itself. After several more days fruitlessly quizzing tech support at the system vendor and finally at Intel itself, I dispatched (30 October 1994) an e-mail query regarding the error to several parties whom I thought would be interested and would have access to a large variety of systems. The message and its consequences were spread worldwide over the Internet within days, and eventually Intel admitted that such errors (which occurred only in floating point division and remaindering operations, with unusual denominators) were the result of a production flaw in nearly all (over a million) of the Pentium CPUs produced to that time. Although the error was quite rare and often of extremely small magnitude, a crisis in public relations and consumer confidence ensued, and Intel eventually agreed to replace all such chips with corrected versions, at the company's expense. In January 1995, Intel announced (PC Week, 1995) a \$475 million accounting charge to cover the cost of the episode. More elaborate technical details may be found in Sharangpani and Barton (1994) and in Coe (1995). One final point of interest in this regard is that the original error of 13 June 1994, the incorrect count of primes, appears to have originated in the use of the fmod remaindering instruction in the sieving process; fmod in turn invokes one of the fdiv family of instructions, which is then executed in the FPU hardware divider.

After this tempest began to settle (mathematicians in general, and this one in particular, are not accustomed to being besieged by inquiries and visits from network news, the BBC, the Washington Post, the Wall Street Journal, and the New York Times, as well as journalists from France, Australia, and Malaysia), attention returned to the work at hand. With commendable haste, Intel provided a replacement chip for the errant Pentium (as well as one for a colleague's system) and also supplied a 90-MHz Pentium system to help make up for lost time. Naturally, all remaining calculations were carried out in duplicate, and the wisdom of this caution was confirmed when other discrepancies appeared between duplicate runs. Twice the errors were tracked to intermittently defective memory (SIMM) chips; parity checking had failed to report either error. On another occasion, a disk subsystem failure generated a wholesale lot of incorrect, yet plausible data. In the most recent instance, a soft memory error appears to be the culprit.

Although many may dismiss machine errors such as these as of no practical consequence (except to mathematicians) or as evidence of the unreliability of personal computers, I believe there is a more important conclusion to be drawn. Any significant computation, for which there is no simple check available, should be performed in duplicate, preferably on two different systems, using different CPUs, hardware, operating systems, application software, and algorithms. In practice, it is difficult to obtain this degree of independence; but certainly, one must be suspicious of the result of any single, lengthy machine computation, whether it is performed on a personal computer or the world's finest supercomputer. As we tell our students---check your work!

COMPUTATIONAL RESULTS

Table 1 contains a brief summary of the computational results, including the counts $\pi_2(x)$ of twin prime pairs; the values of Brent's (1975) $r_3(x)$,

$$(7) \quad r_3(x) = L_2(x) - \pi_2(x) ;$$

the partial sums $B(x)$ of (5); and the extrapolations $B^*(x)$ of $B(x)$ to the limit according to (4), yielding a sequence of approximations to Brun's constant believed to be of ever increasing accuracy. Note that in the interest of simplicity, both Table 1 and Table 2 use the floating point format (common to most programming languages) for numbers in scientific notation. The slow growth of $r_3(x)$ provides further evidence in favor of the Hardy-Littlewood approximation (2), which itself implies the truth of the conjecture of the infinitude of the twin primes.

Not shown are the counts of primes $\pi(x)$, maintained primarily for checking purposes; note, however, that the resulting data files contain values for $\pi(x)$ for $10^9(10^9)10^{14}$, which may well be one of the most extensive such listings in existence and could be useful for other purposes.

As has been mentioned, the counts $\pi_2(x)$ and the corresponding partial sums $B(x)$ so obtained agreed with all the values previously published by Brent (1975, 1976) to 10^{11} . Beyond that point, a number of the values of $\pi_2(x)$ and $B(x)$ were checked (using an alternating exchange via electronic mail) against preliminary partial results obtained by M. Kutrib and J. Richstein (1995) in a similar calculation. All counts thus checked agreed, and all the partial sums agreed to at least 18S, with residual discrepancies believed to be caused by bugs in the gcc compiler used by the other party. Additional checking mechanisms were incorporated as previously explained.

More detailed results can be obtained from Lynchburg College's anonymous ftp site, machine ID = acavax.lynchburg.edu, user ID = anonymous, password = Internet ID; the corresponding UMT files will be found in a subdirectory of [anonymous.nicely].

One additional result of interest in this regard is the value of $B(10^{14})$ obtained from the ultra-precision arithmetic:

$$B(10^{14}) = 1.82024496813027052889471783861953382834649078217191413 , \\ \text{with at least 41D (and probably 47D) believed to be correct.}$$

BRUN'S CONSTANT AND THE ERROR ANALYSIS

The extrapolated sum $B^*(10^{14})$ is believed to produce the most accurate value known to date for Brun's constant,

$$(8) \quad B = B(+\infty) = 1.90216 05778 \pm 2.1 \times 10^{-9}$$

The stated error estimate corresponds to one standard deviation in the following sense. Based on the evidence presented below, it is believed that if the algorithm used to derive this error estimate $\sigma(x)$ is applied to a large number of randomly chosen values of x (for each of which $B(x)$ is computed and then extrapolated to $B^*(x)$), the true value $B(+\infty)$ of Brun's constant will lie between $B^*(x) - \sigma(x)$ and $B^*(x) + \sigma(x)$ about 68 % of the time; between $B^*(x) - 2\sigma(x)$ and $B^*(x) + 2\sigma(x)$ about 95 % of the time; between $B^*(x) - 3\sigma(x)$ and $B^*(x) + 3\sigma(x)$ about 99 % of the time; etc., just as would be expected of the behavior of the standard deviation of a normally distributed variable.

TABLE 1. Counts of twin primes and estimates of Brun's constant

x	$\pi_2(x)$	$r_3(x)$	B(x)	$B^*(x)$
8e10	182855913	-984.74	1.796977508288414	1.902160400157630
9e10	203710414	-6872.36	1.797468808649461	1.902160532806004
1e11	224376048	-7183.32	1.797904310955119	1.902160541422583
2e11	424084653	-8611.89	1.800681441692738	1.902160557807120
3e11	615885700	-11077.61	1.802238425610275	1.902160567207455
4e11	802817718	-23093.64	1.803314522594797	1.902160635784981
5e11	986222314	-13877.92	1.804133287736837	1.902160595672241
6e11	1166916933	-18008.47	1.804792314084921	1.902160611601456
7e11	1345394380	-23486.68	1.805342641847864	1.902160627757985
8e11	1521998439	-22360.26	1.805814337650692	1.902160625580581
9e11	1696987738	-14624.66	1.806226588713636	1.902160608308483
1e12	1870585220	-25353.18	1.806592419175883	1.902160630437725
2e12	3552770943	46121.50	1.808931049664746	1.902160521956607
3e12	5173760785	34043.13	1.810246818931813	1.902160531376364
4e12	6756832076	-19173.40	1.811158095237466	1.902160561178057
5e12	8312493003	-17742.07	1.811852563407868	1.902160559627288
6e12	9846842484	4228.51	1.812412158420305	1.902160551021909
7e12	11363874338	-28648.11	1.812879924669885	1.902160561654484
8e12	12866256870	-50032.56	1.813281195346818	1.902160567365323
9e12	14356002120	-58481.45	1.813632156341301	1.902160569662763
1e13	15834664872	-66566.94	1.813943760684607	1.902160571080154
2e13	30198862775	-99750.43	1.815940298662853	1.902160579010763
3e13	44078684643	-172868.71	1.817066852499448	1.902160583828792
4e13	57657248284	-127115.12	1.817848459999912	1.902160581536889
5e13	71018282471	-72805.14	1.818444902933538	1.902160578986490
6e13	84209699420	8870.37	1.818926002994568	1.902160575928305
7e13	97262712867	-75675.28	1.819328479041238	1.902160578303203
8e13	110198743491	-68932.89	1.819673984268776	1.902160577983921
9e13	123033833767	-33794.18	1.819976357302832	1.902160577217768
1e14	135780321665	-56770.51	1.820244968130271	1.902160577783278

The error estimate $\sigma(x)$ is computed as follows. Brent (1975) conjectures on theoretical grounds that the values of

$$(9) \quad P(x) = \sqrt{x} \cdot \ln(x) \cdot [B^*(x) - B(+\infty)]$$

are asymptotically normally distributed with mean $o(1)$ and standard deviation $(8c_2)^{1/2}$. From the results of my computations, I evaluated $P(x)$ at each of the (more than 10^5) tabulated data points, using $B^*(10^{14})$ for $B(+\infty)$. The resulting distribution was in reality only roughly normal, with $\mu = 0.01351$, $\sigma_p = 0.6703$, skewness $a_3 = -0.6809$, and kurtosis $a_4 = 1.7859$. The standard deviation σ_p differed signifi-

cantly from the value of 2.2981 predicted by Brent (1975). However, Brent (1975) based his ultimate error estimate not on the standard deviation of $P(x)$, but on its absolute upper bound (over all tabulated points $\geq 10^4$) of approximately 3.5.

Nonetheless, it seems preferable to base the error bound on the global behavior of $P(x)$, rather than its behavior at one extreme point. Thus one might hope that the standard deviation (in some sense) $\sigma(x)$ of $B^*(x) - B(+\infty)$ could be deduced from (9) as

$$(10) \quad \sigma(x) = \frac{\sigma_P(x)}{\sqrt{x \ln(x)}},$$

where $\sigma_P(x)$ is the standard deviation of the distribution of $P(t)$ over all tabulated values of $t < x$, using $B^*(x)$ in place of $B(+\infty)$. This would then provide the source of the final error estimate quoted in (8):

$$(11) \quad \sigma(10^{14}) = \frac{0.6703}{\sqrt{10^{14}} \cdot \ln(10^{14})} \approx 2.08 \times 10^{-9}$$

For purposes of comparison, the error estimate generated using Brent's (1975) logic would be

$$(12) \quad E_B = \frac{3.495}{\sqrt{10^{14}} \cdot \ln(10^{14})} \approx 10.84 \times 10^{-9}$$

since the maximum of $|P(x)|$ would still occur at $x = 860000$ with a value nearly identical to Brent's.

Certainly, the use of equation (10) as thus interpreted merits a healthy dose of skepticism. As a practical test of its validity, I also applied it separately to each decade value of x in $[10^4, 9 \times 10^{13}]$, calculating $\sigma_P(x)$ for the distribution of $P(t)$ over all tabulated values $t < x$ (using $B^*(x)$ for $B(+\infty)$); and then from (10), $\sigma(x)$, the error estimate for $B^*(x)$ based on the data points $< x$. In other words, for each such decade value x , I computed an error estimate using the same algorithm which produced the error estimate quoted in (8). This error estimate was then compared with the best known estimate for the true error in $B^*(x)$, namely $B^*(x) - B^*(10^{14})$. Decade rather than linear intervals were chosen so that the sample would be logarithmically distributed and thus presumably less influenced by the fact that values near 10^{14} would show artificially low error rates (due to the necessity of treating $B^*(10^{14})$ as the best known value for $B(+\infty)$).

Partial results are shown in Table 2, which lists the values of x , $\sigma_P(x)$, $\sigma(x)$, and the error $E(x)$ scaled to $\sigma(x)$:

$$(13) \quad E(x) = \frac{B^*(x) - B^*(10^{14})}{\sigma(x)}.$$

Of the complete set of 90 values of x thus sampled, $|E(x)|$ was less than $\sigma(x)$ in 62 cases (69 %); less than $2\sigma(x)$ in 86 cases (96 %); and less than $3\sigma(x)$ in all cases. Furthermore, varying the presumed ultimate value of $B(+\infty)$ by as much as plus or minus $\sigma(10^{14})$ from $B^*(10^{14})$ produced no appreciable change in this distribution of errors; neither did changing the granularity of the data points from 10^9 to 10^{10} . Thus, $\sigma(x)$ indeed appears to be a reliable predictor of the error in $B^*(x) - B(+\infty)$, behaving in a manner similar to the standard deviation of a normally distributed variable.

TABLE 2. Success of $\hat{\sigma}(x)$ as an error predictor

x	$\sigma_p(x)$	$\sigma(x)$	E(x)
1e04	1.04287	1.13228e-03	1.26966
1e05	1.17395	3.22452e-04	0.00842
1e06	1.17952	8.53762e-05	-2.89571
1e07	1.46618	2.87656e-05	0.96245
1e08	1.30196	7.06790e-06	1.04135
1e09	1.29540	1.97673e-06	-0.17122
1e10	1.23791	5.37619e-07	-0.41209
8e10	1.00181	1.41084e-07	-1.25901
9e10	1.13094	1.49458e-07	-0.30094
1e11	1.11493	1.39200e-07	-0.26121
2e11	0.93614	8.04440e-08	-0.24832
3e11	0.85703	5.92089e-08	-0.17862
4e11	1.14191	6.75853e-08	0.85820
5e11	0.84107	4.41554e-08	0.40514
6e11	0.83010	3.95152e-08	0.85583
7e11	0.87371	3.82879e-08	1.30523
8e11	0.80947	3.30204e-08	1.44751
9e11	0.72422	2.77339e-08	1.10064
1e12	0.78024	2.82378e-08	1.86468
2e12	1.56969	3.91870e-08	-1.42462
3e12	1.15503	2.32114e-08	-1.99932
4e12	1.17522	2.02503e-08	-0.82000
5e12	1.03070	1.57638e-08	-1.15175
6e12	0.84056	1.16630e-08	-2.29455
7e12	0.96812	1.23716e-08	-1.30369
8e12	1.08938	1.29636e-08	-0.80363
9e12	1.11698	1.24824e-08	-0.65056
1e13	1.11802	1.18111e-08	-0.56753
2e13	1.08612	7.92982e-09	0.15479
3e13	1.15637	6.80338e-09	0.88860
4e13	0.89701	4.52841e-09	0.82890
5e13	0.82343	3.69178e-09	0.32592
6e13	0.95020	3.86663e-09	-0.47974
7e13	0.78574	2.94591e-09	0.17649
8e13	0.74248	2.59307e-09	0.07738
9e13	0.71818	2.35609e-09	-0.24002

Admittedly, this technique of error estimation is long on pragmatism and short on rigor; only a theoretical breakthrough or an enormous amount of additional computation will decide its ultimate fate. This is hardly unexpected when dealing with Brun's constant, the twin primes conjecture, and the Hardy-Littlewood approximation, all of which have proved singularly resistant to analytical attack.

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Notes on the Distribution of *Pseudotremia cavernarum* Cope

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Pseudotremia cavernarum, the Ellett Valley Milliped, has been found only in caves in Ellett Valley, Montgomery County, Virginia. This cave-adapted milliped is currently considered threatened in Virginia (Hoffman 1991). *P. cavernarum* was originally described by Cope (1869) and the identity of the species was clarified by Hoffman (1958). At the time of Hoffman's redescription, the species was known only from Erhart Cave in Ellett Valley. Erhart cave was destroyed in the 1970's by quarrying. *P. cavernarum* was later reported from Dave's Cave by Holsinger and Culver (1988) and in Aunt Nellie's Hole, Dave's Cave, and Heartbeat Cave by Linzey (1990). These caves are all close to the site of Erhart Cave.

Seven caves (Aunt Nellie's Hole, Dave's Cave, Old Mill Cave, Slusser's Chapel Cave, and 3 unnamed caves: A, B, and C) in Montgomery County, Virginia were sampled between May and July 1994 to determine the distribution of the species in the Ellett Valley area. These caves are the closest known sites to the former location of Erhart Cave. Caves were visited primarily in May because *P. cavernarum* apparently emerges from crevices in Spring to mate (Hoffman, 1991). Aunt Nellie's Hole, Mill Creek Cave, Old Mill Cave, and Slusser's Chapel Cave are listed or described in Douglas (1964) and Holsinger (1975). Unnamed Cave A is approximately 1.2 km from Dave's Cave. Unnamed Caves B and C are within 2 km of Slusser's Chapel Cave.

P. cavernarum was present in two caves: Unnamed Cave A and Dave's Cave. In this study, *P. cavernarum* was found in all sampling months, but individuals were more common in May. The milliped *Pseudotremia hobbsi* was found in Unnamed Cave B. Millipedes (*Trichopetalum* sp.) also were present in Aunt Nellie's Hole and Slusser's Chapel Cave. No millipedes were found in Old Mill Cave or Unnamed Cave C.

Based on all known cave records, *P. cavernarum* is apparently restricted to 4 caves (Aunt Nellie's Hole, Dave's Cave, Heartbeat Cave, and Unnamed Cave A) near the former location of Erhart Cave. While the species probably has a small geographic distribution, lack of intensive field sampling has certainly led to underestimation of both the range and number of caves harboring populations of *P. cavernarum*. Reliable estimation of the distribution of *P. cavernarum* will require repeated sampling of potential habitats, particularly in early Spring (February-May).

All millipedes found in this study were on damp organic material (usually wood). Damp organic debris may be an important food source for *P. cavernarum*. Caves harboring populations of *P. cavernarum* should be managed to maintain the input of organic material to the system. Small caves and crevices in limestone outcrops should be included in future studies. Presences of *P. cavernarum* in very small caves (e.g., Unnamed Cave A < 15 m long) suggests populations may be found in small

fissures and solution channels in limestone as well as larger caves. *P. cavernarum* should remain on Virginia's endangered species list pending an extensive survey for additional localities for the species.

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Network Contraction in R^{n+1}

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ABSTRACT

This paper presents the principles and essential elements of DINERⁿ⁺¹, a simple scheme for minimizing the storage requirements of a network of observed data in R^{n+1} , without significant loss of the informational value of the data set. DINERⁿ⁺¹ partitions a subject network into a set of contiguous atomic sub-networks, all of which share a common interpolation functional form. Generalizability and extendability of such a network contraction scheme to a wide variety of contexts is of considerable interest in most scientific and technological applications.

INTRODUCTION

Let $D_N^{n+1} = \{(x_i, d_i) R^{n+1} | x_i \in R^n, d_i \in R; i = 1, 2, \dots, N\}$ denote a set of N discrete points in R^{n+1} , which represents an observation of some system. The real numbers, d_i , represent some information about the system at space-time locations $x_i \in R^n$. Each point-value pair: (x_i, d_i) , may then be called a digital information node; in which case D_N^{n+1} is an N -node digital information network in R^{n+1} .

Computational physics, which deals largely with simulation modeling of physical systems, employs such digital information networks to model physical systems. The number N , of nodes in such network models required to realistically capture the essence of a practical physical system is usually very large; strategies must be devised to significantly minimize N , without losing the essential characteristics of the physical system being modeled.

The information super-highway bandwagon, which is currently parading everywhere, promising instant information on any and everything, from any and everywhere, to any and everyone, must be ready to store and fetch very large amounts of information across a network of information consumers/producers. Its practicality demands, among other things, efficient schemes for minimalist information representation.

This paper proposes and demonstrates a simple, reasonably accurate, fast and efficient scheme, called DINERⁿ⁺¹, for minimizing digital information networks in R^{n+1} .

NETWORK BASICS

A network is generally defined as a domain of elements (called nodes) that are connected by links (called branches or arcs). A network node may be a source, sink or transhipment point for the network's information stream. A branch, on the other hand, is like a conduit for information flow, but one which may also process (that is, manipulate) the information as it flows along the branch. The nature of a network's information stream depends on the system being modeled by the net-

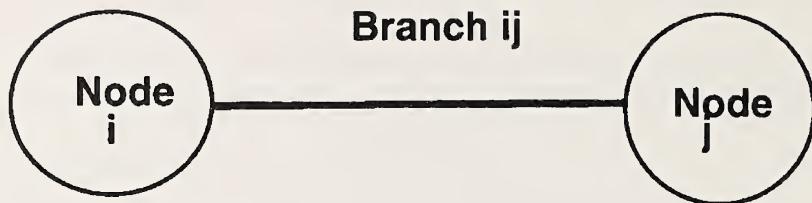


FIGURE 1. Schema of a Network Branch.

work, and the number and distribution of the nodes and branches in a network depend on the complexity of the subject system.

Regardless of the space-time dimensionality of a network, each network branch is always characterized by a pair of nodes, one of which may be called the head- and the other the tail-node (see Figure 1). The branch itself can be modeled as a transformer whose input is the head-node information and whose output is the tail-node information. A collection of connected branches linking two nodes that are not next neighbors is called a path (or a tree); it may be considered to be a macro-branch, and, therefore, a complex (usually non-linear) transformer of the information at its end nodes. In this paper the word branch refers to either a simple or a macro branch. Further, a branch interpolation function is defined as the functional form of a branch's transformer. Given the head and/or tail node, a branch interpolation function should be able to present, on demand, any intermediate nodes on the branch, and, therefore, all the information of the sub-network represented by the branch.

A network may be partitioned into contiguous sub-networks. This is usually done by selecting some subset of the network's nodes as anchor nodes, and creating a new network of such anchor nodes. Each sub-domain of the original network, bounded by anchor nodes and anchor-node-branches, is then called a partition of the original network. Let:

$$D_N^{n+1} = \sum_{j=1}^L \left(S_M^{n+1} \right)_j \quad (1)$$

where: $L < N$; $(S_M^{n+1})_j = \{(x_k, d_k) \in R^{n+1} \mid x_k \in R^n, d_k \in R; k = 1, 2, \dots, M\}$; and, desirably, $M < < N$. $(S_M^{n+1})_j$ is called a partition or sub-network of D_N^{n+1} . In the same way that a branch interpolation function was defined, a partition interpolation function may be defined, using the bounding anchor nodes, such that the function interpolates all nodes of the original network that are resident in the partition.

THE NETWORK CONTRACTION PROBLEM

The digital information network contraction problem may be stated simply as follows: Given D_N^{n+1} , find the smallest network:
 $C_M^{n+1} = \{(x_k, d_k) \in R^{n+1} \mid x_k \in R^n, d_k \in R; k = 1, 2, \dots, M\}$, such that: $M < N$,

and $C_M^{n+1} (\subseteq D_N^{n+1})$ captures all the informational value of D_N^{n+1} . This is a fundamental problem in computational physics, image coding/decoding, digital data compression, and similar emergent signal processing technologies of modern information science. Although related, the above problem is quite different from the basic problem of "Minimal Networks Theory" (Ivanov and Tuzhilin 1994) encountered in minimal spanning tree and shortest route analyses.

Several significant but independent strides, (Schumaker and Webb, 1994), (Meyer, 1993), (Barnesly, 1993) and (Thompson and Weatherill, 1993), have already been made towards solving this network contraction problem in several application contexts, but all such efforts are for the most part disjointed and difficult to extend across application areas. For example, a digital data compression scheme seems to bear no relationship whatsoever to a computational physics grid technology for, say, fluid flow simulation, and vice-versa. Yet, each of those two applications is precisely an exercise in network contraction. A unified solution which is extendable within and across application contexts is clearly needed.

NETWORK CONTRACTION STRATEGIES

If D_N^{n+1} contained several spatial and/or temporal redundancies that are not necessary for specifying the network's informational value, then removal of all such redundancies should minimize D_N^{n+1} , without loss of its informational value. Alternatively, and perhaps even concurrently with redundancy removal, it may be possible to construct a new representation format for the informational value of D_N^{n+1} , which makes significantly less demand on storage resources. For instance, instead of the N nodes of D_N^{n+1} one could seek to represent the network's information with just a subset of the network's boundary nodes plus an interpolation functional form which can compute any of the other nodes of D_N^{n+1} , on demand. The storage required for such boundary nodes and for the interpolation functional form should be significantly less than was needed for the original D_N^{n+1} network. This latter representation, when realizable, is the ideal (or optimal) contraction of D_N^{n+1} . But it is an ideal that is often unrealizable for most systems of scientific and technological interest.

A key reason for the unrealizability of the optimal (that is, single functional) representation of system information networks lies in the fact that, except for the simplest and usually trivial systems, it is rather difficult to describe a system using a single functional form. Usually an infinite set (or a very large collection) of functional forms is needed to represent most systems of any practical scientific and technological interest. However, it may be possible, in the manner discussed earlier in this paper, to partition a D_N^{n+1} network into a set of sub-networks, each of which may be more amenable to optimal contraction. Among the sub-networks, $(S_M^{n+1})_j$, it may be further possible to identify some that are similar, that is, they have identical functional forms but differ in boundary node and/or function coefficient values. Such similar sub-networks are said to be redundant. Network redundancies can be removed by representing the redundant sub-networks as multiple instances of a single parametric sub-network. Partitioning, such as is described above, appears to be much more practicable than ideal contraction. It is the method of choice for most currently popular network contraction methods, such as wavelet schemes, (Meyer, 1993) and fractal compression methods, (Bar-

nesly, 1993), and (Jeff, 1994). And such partitioning can be accomplished with readily available schemes such as Delaunay triangulation.

Within the context of network contraction, as has been discussed above, a contraction ratio parameter Γ , may be defined as follows:

$$\Gamma = (\text{Original Network Storage}) / (\text{Contracted Network Storage}) \quad (2)$$

The objective of a practical network contraction scheme is to maximize Γ ; and a general strategy is to construct a feasible partitioning scheme to decompose a given network into a set of sub-networks, such that simple functional forms may be found to model each of the partitions. Successful application of these decomposition methods will depend on the partitioning strategy in use, as well as on the partition interpolation functional forms possible.

DINERⁿ⁺¹

In light of the above discussions, a simple network contraction scheme will now be proposed. Called DINERⁿ⁺¹: Digital Information Network Encoder in Rⁿ⁺¹, its objective is to partition a given D_Nⁿ⁺¹ into a set of "atomic" sub-networks, each of which is then optimally represented with the same partition interpolation functional form. Such atomic partitions are extracted using the LBM algorithm (discussed below) to mark a subset of the nodes of D_Nⁿ⁺¹ as anchor nodes. The network C_Mⁿ⁺¹, (M < N), of boundary and interpolant anchor nodes thus obtained is a contraction of D_Nⁿ⁺¹; it is a network of anchored atomic partitions. The DINERⁿ⁺¹ process consists of the following steps:

- (a) Distinguish the nodes of D_Nⁿ⁺¹ into two major types: boundary (those which define the boundaries of the system being modeled) and interpolant (all other nodes of the system).
- (b) Apply the LBM anchoring algorithm to identify and mark a subset of the boundary nodes as anchor nodes;
- (c) Apply the LBM anchoring algorithm to identify and mark interpolant anchor nodes, if any; and
- (d) Represent each atomic partition of D_Nⁿ⁺¹ with the predictor-corrector partition interpolation functional form,

$$(L_j^{n+1} + E_j^{n+1}) \text{ such that:}$$

$$d_j^{n+1} = L_j^{n+1} + E_j^{n+1} \quad (3)$$

where d_jⁿ⁺¹, is the informational value of the jth node in the partition.

The predictor L_jⁿ⁺¹, is a linear interpolation functional anchored on the partition's boundary nodes. In general, for any D_Nⁿ⁺¹, L_jⁿ⁺¹ is the functional of a uniform geometrical form bounded by (n+1) anchor nodes. For D_N², L_j² is a straight line joining the two anchor nodes; for D_N³, L_j³ is a planar surface connecting three anchor nodes; and for D_N⁴, L_j⁴ is a tetrahedral volume with four anchor nodes.

The corrector E_jⁿ⁺¹, is a generally non-linear interpolation functional, which is used either to fit (in the case of a known d_jⁿ⁺¹ distribution), or to predict (in the

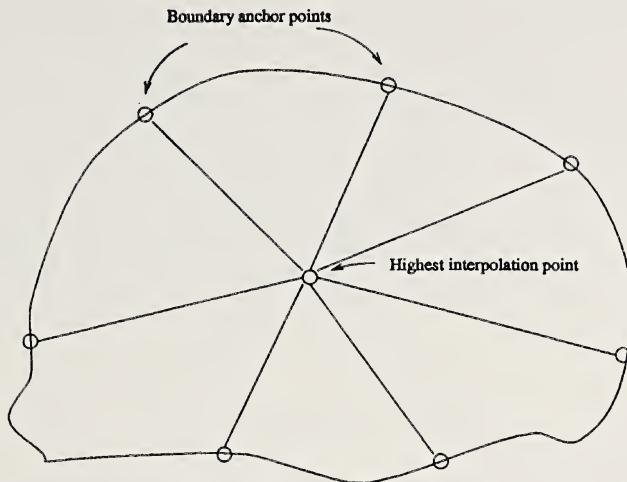


FIGURE 2. A typical LBM partitioning of a D^3 network

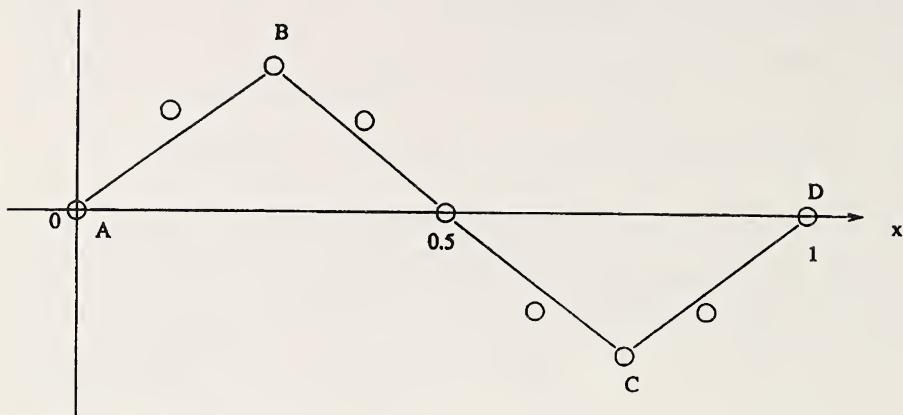
case a simulation model), the error-distribution ($d_j^{n+1} - L_j^{n+1}$). Because the boundary nodes of an atomic partition are always captured exactly, E_j^{n+1} is always zero-valued at an atomic partition boundary. Frank (1987) discusses several general fitting methods that could be used to define E_j^{n+1} .

L_j^{n+1} and E_j^{n+1} are each atomic partition invariant in R^{n+1} . That is, any atomic partition of D_N^{n+1} has exactly the same L_j^{n+1} and E_j^{n+1} functional forms. This fact is exploited in DINERⁿ⁺¹, as a redundancy removal mechanism, to increase the network contraction ratio: Γ

LINEAR BASE MINMAX (LBM) ANCHORING ALGORITHM

Given a set of nodes, the LBM anchoring algorithm used to identify and mark the set's anchor nodes is implemented as follows:

First, identify one of the boundary nodes in the set as the source (or inflow) node, and another one (usually the one spatially and/or temporally farthest removed from the source node) as the sink (or outflow) node. The choice of source and sink nodes may be quite arbitrary, particularly if the subject set of nodes does not describe a flow system. The source and sink nodes are marked as the first set of anchor nodes. Then, using the current set of anchor nodes as the boundary nodes, and all the other nodes as interpolant nodes, locate the node in the set which has the maximum informational value, greater than the informational value of any of the boundary anchor nodes. If such a node exists, mark it as an anchor node and connect it with branches to each of the other anchor nodes, thereby partitioning the given set into sub-networks (see Figure 2). If such a maximum node does not exist, find the node in the set which has the minimum informational value, lower than the informational value of any of the bounding anchor nodes. If such a minimum node exists, mark it as an anchor node and connect it with a branch to each of the other anchor nodes. If neither a maximum nor a minimum node is found among the interpolant nodes of the given set, then the set of nodes represents a single "atomic" set (or network). Repeat this partitioning process

FIGURE 3. Schema of a D^3 network

separately for each of the sub-networks, until the original set has been partitioned into a set of "atomic" sub-networks, each of which is bounded by anchor nodes.

DINERⁿ⁺¹: A SIMPLE EXAMPLE

To demonstrate DINERⁿ⁺¹, consider the simple D_N^2 schematized in Figure 3. It is a period of a discretized sine wave. Imagine that it represents an experimental observation of some system information, which was obtained in that discrete form. Further, imagine that the observer did not have a priori knowledge of the functional form of the data distribution. If, say, one hundred (100) data nodes were collected, the problem here would be to find the smallest network C_M^2 , ($M < 100$), which captures the information carried by the original D_{100}^2 network.

Of course, if the observer could visualize the data, he/she might immediately be able to fit a sine wave function to the distribution. The result would be C_2^2 , a two-node network with one partition defined by the interpolation function: $d_j = a \sin(2\pi x_j)$, $0 \leq x_j \leq 1$, and anchored at the boundary nodes A and D. That would correspond to ideal contraction. However, an observer of a system usually may not be able to completely visualize the discrete data representation of the system, or perhaps may not intuitively be able to recognize a single functional form with which to model such data. A scheme such as DINERⁿ⁺¹ must then be used.

In this simple example there are only two boundary nodes, A and D. Automatically they become the source and sink nodes, respectively, as well as the boundary anchor nodes. Applying the LBM anchoring algorithm to the set of boundary nodes A, D and the interpolant nodes of the data set, the node, B, with the highest data value is identified as the next anchor node. Branches, AB and BD are drawn to connect B to A and to D, respectively. The interpolant nodes between A and B form a sub-network, and those between B and D form a second sub-network; thus, the anchor nodes A, B and D have partitioned D_{100}^2 into two sub-networks. Further application of the LBM anchoring algorithm to the sub-network bounded by A and B, yields no other sub-network, so the AB sub-network is atomic; but, on the BD sub-network, the node C is identified as a minimum node, since its data value is smaller than that of any other node in its sub-network. C is therefore an

anchor node, which partitions the BD sub-network into two sub-networks, each of which is seen to be atomic.

The original network D_{100}^2 , has now been partitioned into three atomic sub-networks. AB, BC and CD bounded by the four anchor nodes, A, B, C and D. Each of the three partitions is defined by its two bounding anchor nodes and the same partition interpolation functional: $(L_j^2 + E_j^2)$.

Let: $z_j = (x_j - x_h)/(x_t - x_h)$ represent the normalized "distance" between the jth interpolant node in a partition and the partition's source node x-coordinate x_h , and let d_h and d_t be the data values at the partition's source and sink nodes, respectively. The components of the partition interpolation functional are:

$$L_j^2 = d_h + (d_t - d_h) \cdot z_j \quad (4)$$

$$E_j^2 = a \cdot \sin(\pi/2) z_j^b \cos(\pi/2) z_j^c \quad (5)$$

The form of E_j^2 chosen here is by no means unique. Other, and perhaps more general, fitting methods, (Frank, 1987), may be exploited. But once chosen, the form of E_j^2 applies to any atomic partition of any D_N^2 network, with only the values of the partition interpolation function coefficient array elements (a,b,c), differing among the partitions. The contraction ratio for a DINER² scheme which minimizes a D_N^2 to a C_M^2 , using the interpolation functional forms suggested above, is:

$$\Gamma = 2N/(5M-3) \quad (6)$$

Since the original D_{100}^2 network was contracted to C_4^2 , a network composed of the four anchor nodes, A, B, C and D, which define three partitions, each of which is represented by two bounding anchor nodes and an array of three numeric coefficients, the realized contraction ratio is approximately $\Gamma = 12$. The ideal contraction C_2^2 , for the same network would have yielded a contraction ratio: $\Gamma = 40$.

CONCLUDING REMARKS

DINERⁿ⁺¹ is a simple, generally consistent and easily programmable scheme for contracting digital information networks, with minimal loss. It is applicable to simple as well complex systems in a wide variety of contexts and dimensionality. Because the functional forms needed to represent a sub-network (or partition) of a D_N^{n+1} may be analytical, fractal or any other type, DINERⁿ⁺¹ can draw from the strengths of any available knowledge base on discrete data fitting and functional analysis.

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VIRGINIA ACADEMY OF SCIENCE ACADEMY CONFERENCE

May 25, 1995

The meeting of the Academy Conference was convened at 4:45PM with 103 members present.

President - Elsa Q. Falls

President Falls recognized the LAC Co-Chairs Rae Carpenter and Dick Minnix for the superb job they and their committee have done in arranging the annual meeting.

Next year's meeting will be held at VCU and the Chair of the LAC will be Tom Haas. The meeting will be held May 21-24.

Finance and Endowment Committee - Art Burke

Art Burke announced that the finances of the Academy are in good fiscal order. The auditors report for 1994 indicated that everything is okay.

Nominating Committee - Gerald Taylor

Gerald Taylor introduced the new officers:

Tom Sitz - President

Dean Decker - President Elect

Carolyn Conway - Vice President

Joe Rudmin - Secretary

Greg Cook - Treasurer

Awards Committee - Carolyn Conway

Student awards were presented to students in sections that had completed their sessions.

Resolution -Importance of Laboratory in Science Education

Marion Lobstein introduced the resolution on the Importance of Laboratory in Science Education (attached). She indicated that the current trend in the Commonwealth is to do away with laboratory, and that the purpose of this resolution is to indicate the importance of this experience in science education. The Council approved the resolution at its meeting.

Marion Lobstein made the following motion:

Move that this resolution supporting the importance of laboratory in science education be approved by the Academy Conference, and that this statement be published in the *Virginia Journal of Science* and the *Virginia Scientist*, and be sent to appropriate individuals and groups.

Dean Decker suggested that the resolution also be sent to Science Chairs in the state, since often information does not filter down.

It was also suggested that the resolution be sent to newspapers.

The motion passed unanimously.

The meeting was adjourned at 5:13.

VIRGINIA ACADEMY OF SCIENCE EXECUTIVE COMMITTEE MEETING MINUTES

May 24, 1995

Present: Elsa Q. Falls (President), Thomas O. Sitz (President-Elect), Rosemary Barra (Secretary), Kenneth C. Jacobs (Treasurer), Don Cottingham (VJAS Director), Arthur W. Burke (Chair, Finance and Endowment Committee; Assistant to Executive Secretary-Treasurer), James P. O'Brien (1993-94 President; Chair, Fund Raising Committee), Rae Carpenter (Co-Chair, Local Arrangements Committee - VMI), James H. Martin (Editor, Virginia Journal of Science).

The meeting was called to order at 2:00, and the agenda for the meeting was adopted.

OFFICERS' REPORTS

President - Elsa Q. Falls

President Falls distributed a copy of her report (attached), and emphasized the following points:

The members of the LAC have been great and everything seems to be going well. The major problem so far has been the lack of slide projectors for the VJAS.

A committee has been appointed to review the position of the Associate Director of the VJAS. It consists of Rae Carpenter (Chair), Don Cottingham, Vera Remsburg, Gerald Taylor, Tom Sitz, and Elsa Falls, and the first meeting will be held on June 13.

- Seven nominations have been received for the VAS Trustee Representative to the Science Museum of Virginia: Richard Brandt, Rae Carpenter, Elsa Falls, Golde Holtzman, Jim Martin, Ertle Thompson and Gerald Taylor. President Falls reported that Rae Carpenter may not be eligible since he has previously served on the Board of the Science Museum. She has requested clarification of his eligibility. Elections will be held at the Council meeting today, and President Falls suggested that we nominate three individuals with the third serving as an alternate.

- As a follow up to a question at the last meeting, Elsa Falls reported that the Constitution clearly states the qualifications needed to become a Patron of the Academy. She suggested that the wording in the Constitution be reviewed by the Constitution and Bylaws Committee.

- This year an individual presenting papers in two different sections at the meeting had these papers scheduled for the same time. To take care of this problem for the future, the question "Are you giving papers in other sections?" should be added to the forms.

President-Elect - Thomas O. Sitz

Things are going well, and the LAC is doing a fine job. Only a few mistakes are in the

program. Committee membership for next year will be finalized within the next two weeks.

Secretary - Rosemary Barra
No report

Treasurer - Kenneth C. Jacobs
No change in the membership figures from the previous report.

Past President - James P. O'Brien

Jim O'Brien distributed a report (attached) and emphasized the following points.

- The VAS Membership Brochure has been reprinted, and is available at the meeting.
- Golde Holtzman replenished the supply of T-shirts and mugs for the annual meeting. He suggested that the central office might handle this in the future.

Assistant to Executive Secretary-Treasurer- Arthur W. Burke

Art Burke addressed the concerns raised by Rae Carpenter about the monies being collected during the Fund Raising Campaign. Art proposed the following motion:

The Executive Committee recommends to Council that we have in writing a statement that funds will go as designated by the donor, but that funds may be dispersed as needed on the recommendation of the Trust Committee and with approval by Council. In the interim, funds received will be placed in the Endowed Corpus VJAS Fund for later reallocation. An Ad Hoc committee will be appointed to deal with these matters.

The motion was seconded by Jim O'Brien and passed unanimously.

Art also suggested that a minimum amount must be donated in order for the donor to specifically designate the use of the monies.

VJAS Director Don Cottingham

Don reported that as of this morning, 850 people had registered for the meeting. Everything is going fine, and everyone seems to be satisfied with the arrangements.

Local Arrangements Committee - Rae Carpenter

Rae reported that they had 801 for lunch yesterday (Monday) and the lines did get a little long at times. The students seem to be happy with the food and all of the frisbees have been sold. The bus situation has worked very well. The only major problems are a shortage of pay phones and women's bathrooms.

Old Business

None

New Business

None

The meeting was adjourned at 3:20.

VIRGINIA ACADEMY OF SCIENCE COUNCIL MEETING MINUTES

May 24, 1995

Present:Elsa Q. Falls (President), Thomas O. Sitz (President-Elect), James P. O'Brien (Past President, 1993-94), Rosemary Barra (Secretary), Kenneth C. Jacobs (Treasurer; Councilor, Astronomy, Math and Physics Section), Gerald R. Taylor (Past President, 1991-92; Co-Chair, Constitution and Bylaws Committee; Co-chair, VJAS Search Committee; Nominations and Elections Committee), Vera B. Remsburg (Trustee, Science Museum of Virginia), James H. Martin (Editor, *Virginia Journal of Science*), Judy Niehaus (Chair, Research Committee), Ertle Thompson (AAAS Representative), Carolyn Conway (Awards Committee), Marion B. Lobstein (Councilor, Botany Section; Co-Chair, Public Affairs Committee), Ralph P. Eckerlin, Co-Chair, Public Affairs Committee), J.J. Murray (Chair, Committee on the Environment), Eugene B. Barfield (Councilor, Archeology Section), Scott H. Newton (Agriculture, Forestry and Aquaculture Section), Michael L. Bass (Councilor, Environmental Science Section; Co-Chair, Constitution and Bylaws Committee), Ali Mohamed (Secretary, Agriculture, Forestry and Aquaculture Section), Preston H. Leake (Fund Raising Committee).

The meeting was called to order by President Elsa Falls at 6:10 PM. In the interest of time, President Falls made a motion to modify the agenda so that items that must be dealt with are moved forward on the agenda, and the remaining items will be covered as time allows. Items not dealt with tonight will be postponed until Friday's meeting. The motion on the modified agenda passed. The minutes from the Council meeting on March 4, 1995 were approved.

Historian - Charlotte Webb

Charlotte Webb reported that she has completed two chapters of the History and has drafts of four other chapters. She plans on defending her dissertation at the end of next April.

1996 Local Arrangements Committee - Tom Haas

The 1996 Annual Meeting will be held May 21-24 at Virginia Commonwealth University. Tom Haas reported that the LAC held its first meeting on April 21st, and the next meeting is scheduled for Friday, September 22. He distributed a draft of the general program, and commented that the student commons area has been expanded.

President - Elsa Q. Falls

President Falls announced that there will be at least one VJAS paper presented in each section of the senior academy. She requested that the Constitution and By-Laws Committee revisit the categories of membership and the dues structure, especially with regards to the categories of Patrons and Life Members.

Awards Committee - Carolyn Conway

Carolyn announced that the awards are in place for the VAS, and she made the following motion on behalf of the Awards Committee:

That Gerald Taylor and Golde Holtzman be elected as Fellows of the Academy.

This motion passed unanimously.

VAS Trustee Nominations

President Falls announced that the following individuals have been nominated for the position of VAS Representative to the Science Museum of Virginia.

Richard Brandt
Rae Carpenter
Elsa Falls

Jim Martin
Ertle Thompson
Gerald Taylor

An election was held to determine the three nominees whose names will be submitted to Walter Witchey. He in turn will make a recommendation to the Governor. The nominees for this position are Elsa Falls, Gerald Taylor and Ertle Thompson (alternate).

Motion from the Executive Committee

Art Burke presented the motion passed by the Executive Committee that deals with the monies collected during the Fund Raising Campaign.

The Executive Committee recommends to Council that we have in writing a statement that funds will go as designated by the donor, but that funds may be dispersed as needed on the recommendation of the Trust Committee and with approval by Council. In the interim, funds received will be placed in the Endowed Corpus, VJAS Fund for later reallocation. An Ad Hoc committee will be appointed to deal with these matters.

The discussion that followed centered on the use of the funds that will be collected. Art Burke indicated that the funds are going to be used to support VJAS awards. Gerald Taylor stated that he thought some of the money raised was going to be used to support the Director of the VJAS and other functions not just awards for the VJAS.

Art Burke responded that he believed that the fund raising committee has placed the VJAS awards as its first priority,

Gerald Taylor indicated that the pledges can be designated for different things such as the Fellows. Jim O'Brien agreed and stated that the fund is really just a holding tank for temporary investment.

Gerald Taylor made a motion to amend the motion to indicate that the funds will be placed in the Legacy 75 Fund to be invested in the Investment Company of America.

The amended motion (below) passed unanimously.

The Executive Committee recommends to Council that we have in writing a statement that funds will go as designated by the donor, but that funds may be dispersed as needed on the recommendation of the Trust Committee and with approval by Council. In the interim, funds received will be placed in the Legacy 75 Fund and invested in the Investment Company of America. An Ad Hoc committee will be appointed to deal with these matters.

Resolution - Importance of Laboratory in Science Education

President Falls indicated that the resolution needs to be approved by Council before it can be presented at the Academy Conference. During the subsequent discussion, a few changes were made in the wording of the resolution. Marion Lobstein moved that the modified resolution (attached) be approved by Council, and presented to the general membership of the Academy. This motion passed unanimously.

President-Elect - Tom Sitz

The committee membership will be finalized over the next two weeks.

Nomination Committee - Gerald Taylor

The Nomination Committee did not receive any additional nominations so the list of nominees remains the same.

President - Elsa Falls

The meeting is running smoothly, and the VJAS students seem to be enjoying the program.

Meeting Adjourned at 7:30.

NOTES

NOTES

MEMBERSHIP

Membership in the Academy is organized into sections representing various scientific disciplines as follows:

- | | |
|---|--|
| 1. Agriculture, Forestry and
Aquaculture | 9. Medical Sciences |
| 2. Astronomy, Mathematics and
Physics | 10. Psychology |
| 3. Microbiology and Molecular
Biology | 11. Education |
| 4. Biology | 12. Statistics |
| 5. Chemistry | 13. Aeronautical and Aerospace
Sciences |
| 6. Materials Sciences | 14. Botany |
| 7. Biomedical and General
Engineering | 15. Environmental Science |
| 8. Geology | 16. Archaeology |
| | 17. Computer Science |
| | 18. Geography |
| | 19. Natural History & Biodiversity |

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VIRGINIA ACADEMY OF SCIENCE

APPLICATION FOR MEMBERSHIP

Date _____ Name (Please Print) _____

Phone (_____) _____ E-mail _____ FAX(_____) _____

Address _____

City _____ State _____ Zip _____

Institution or Business _____

Position — Title _____

Fields of Interest — Section No.(s) _____ First No. indicates major interest

Class of Membership Desired _____

Contacted by: _____

Make check payable to **Virginia Academy of Science** and send to: VAS, Science Museum of Virginia, 2500 W. Broad St., Richmond, VA 23220-2054.

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All manuscripts and correspondence should be addressed to the Editor. The Virginia Journal of Science welcomes for consideration original articles and short notes in the various disciplines of engineering and science. Cross-disciplinary papers dealing with advancements in science and technology and the impact of these on man and society are particularly welcome. Submission of an article implies that the article has not been published elsewhere while under consideration by the Journal.

Three complete copies of each manuscript and figures are required. It is also suggested that authors include a 5.25 diskette in IBM compatible format containing a text file (ASCII) of the manuscript. Original figures need not be sent at this time. Authors should submit names of three potential reviewers. All manuscripts must be double-spaced. **Do not** use special effects such as bold or large print.

The title, author's name, affiliation, and address should be placed on a cover page. An abstract (not to exceed 200 words) summarizing the text, particularly the results and conclusions, is required. The text should follow the general format used by professional journals in the author's discipline. Literature cited in the text should follow the name-year format: (McCaffrey and Dueser, 1990) or (Williams et al., 1990). In the Literature Cited section at the end of the article, each reference should include the full name of the author(s), year, title of article, title of journal (using standard abbreviations), volume number and first and last page of the article. For a book, include author(s), year, title, pages or number of pages, publisher and city of publication. Examples:

McCaffrey, Cheryl A. and Raymond D. Dueser. 1990. Plant associations of the Virginia barrier islands. *Va. J. Sci.* 41:282-299.

Spry, A. 1969. Metamorphic Textures. Pergamon Press, New York. 350 pp.

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The Use of Night-Vision Equipment to observe Wildlife in Forested Wetlands

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The College of William and Mary, and

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U.S. Department of the Interior

ABSTRACT

Urban forested wetlands and rural forested wetlands were studied to investigate the effectiveness of night-vision image intensifier equipment in the observation of medium-to-large animals and to investigate if surrounding landscape type influences wetland habitat value. Bats, cats, dogs, owls, deer, and humans were easily observed using the night-vision equipment. Differences in species use between the rural and urban forested wetland were observed. Light levels and noise levels were significantly higher ($p < 0.05$) in the urban versus the rural wetland. We conclude that image intensifier equipment can be used to quantify nocturnal animal activity in different landscape types and that surrounding land use can reduce the habitat value of forested wetlands to certain species.

Keywords: night-vision, image intensifier, forested wetlands, urban, rural, domesticated animals, nocturnal

INTRODUCTION

Nontidal wetlands have long been recognized for their function and value as wildlife habitat. Certain animals are known to spend portions of their lives frequenting wetland areas. In the United States, 50% of all rare, threatened, and endangered wildlife species occur in or depend upon wetlands for survival (Niering, 1988). An estimated 1.4 million ha of palustrine forested wetlands were lost in the United States during the mid-1970's to mid-1980's with the majority of the loss occurring in the southeast (Dahl and Johnson, 1991). The loss of wetland habitat, particularly forested wetland systems, has resulted in a decline in certain animal populations and, in some cases, a shift to introduced species (Harris and O'Meara, 1989). Large tracts of contiguous habitat connected with a diversity of other wetland types is considered of high value to wildlife (Forsythe and Roelle, 1990), while fragmentation of habitat by development has been shown to impact some species (Oxley et al., 1974; Harris and Vickers, 1984; Harris, 1985; Blackner, 1986; Dickman and Doncaster, 1989).

Regulations such as the Clean Water Act of 1972 generally restrict encroachment into wetlands, yet do not regulate development along the wetland periphery. Urban development can literally encircle a wetland system with residential, industrial, or commercial construction encroaching to the wetland/upland interface resulting in isolated wetland pockets without forested buffers. While wildlife management experts recognize landscape and watershed level influences, there is a perception amongst the

general public that protection of the wetland area while developing the adjacent upland can be accomplished with minimal impact to the functions associated with the wetland. However, residential developments are generally accompanied by an increase in noise and light levels, an increase in human activity, a loss of upland forested habitat, and the introduction of domesticated dogs and cats. These activities may cause a reduction in native animal use of the wetland and/or a shift from native animal populations to domesticated animals.

Flash photography, red-light observation, radio-tracking, and baiting all have been used to study behavior of nocturnal animals (Dickman, 1982; Brown et al., 1988; Wolfe and Summerlin, 1989; Daly et al., 1992). However, the usefulness of these methods is limited because all likely result in a modification of the animal's behavior. Night vision devices are sensitive to electromagnetic wavelengths outside of the visible light band (approximately 0.4 - 0.7 microns) and thus, detect electromagnetic wavelengths or frequencies beyond the range or below the threshold of vision. The night-vision equipment used in this study are considered image intensifiers and allows covert observation of the natural activity of medium to large animals.

The purpose of this study is to investigate the use of night-vision equipment in the observation of wildlife and to explore the hypothesis that surrounding land use may influence nocturnal animal activity.

MATERIALS AND METHODS

Two sites were selected for observation. One site (urban) was located in Newport News, Virginia and was surrounded by a single family housing development. The second site (rural), York County, Virginia, was part of the Colonial National Historic Park. Both sites were approximately 1.2 ha in size and were mapped by the U.S. Fish and Wildlife Service National Wetlands Inventory. The wetlands were classified as palustrine forested broad-leaved deciduous temporarily flooded (PFO1A) (Cowardin et al., 1979). The dominant vegetation of each site was red maple, *Acer rubrum*, sycamore, *Platanus occidentalis*, hornbeam, *Carpinus caroliniana*, and golden ragwort, *Senecio aureus*.

Three observation areas were selected within each wetland with one observer at each area. Each observer was equipped with a pair of PVS-5 night-vision goggles, an infrared aiming light, a 3x night vision pocket scope, and a hand-held two-way radio. The PVS-5 night-vision goggles have a 40° circular field of view and a range of 50 m at an illumination of 0.0003 lumens/m² for man-sized objects. The 3x night-vision pocket scope has a range of 300 m and the infrared aiming light has a range of 150 m. The infrared aiming light was used for directing other observers to a particular site for positive identification of an object. Each site was observed from dusk to midnight once in the spring, summer, and fall (May 18,19; August 10,11; October 11,12, 1992). The dusk to midnight observation period was selected because the majority of nocturnal animals are most active during this time (Alkon and Saltz, 1988; Longland, 1990). Sites were visited on consecutive nights in order to minimize variability in climate and moonlight. Time of observation was noted for each animal. Noise level from the 20 to 20,000 Hz frequency range was measured each sample night with a Simpson Sound Level Meter Type 886 and recorded in decibels. Light level was measured each sample night using a LI-190SB Quantum Sensor and was recorded in Einsteins per 30 minutes

TABLE 1. Bat activity in minutes by hours after sunset between urban and rural wetlands sites.

Hours after Sunset	Bat Activity (min.)	
	Urban	Rural
1	15	25
2	48	45
3	46	15
4	5	0

TABLE 2. Species, number, and time of activity (in minutes) of animals in both rural and urban wetland sites.

Species	Rural (number, time)	Urban (number, time)
Dogs	0	2 (35 minutes)
Humans	0	3 (24 minutes)
Cats	0	2 (65 minutes)
Deer	8 (35 minutes)	0
Owls	2 (10 minutes)	0
Bats	6 (85 minutes)	13 (114 minutes)

per square meter and converted to lumens per square meter. Both sound level and light level meters were placed in the center of the site at the forest floor.

RESULTS

Six species were observed resulting in 130 minutes of activity in the rural wetland and 238 minutes of activity in the urban wetland. Bats (family Vespertilionidae) were the only animals observed in both rural and urban wetlands across the seasons and were the animal most observed with 114 minutes in the urban wetland and 85 minutes in the rural wetland. Significantly longer periods of bat activity were observed in the urban versus the rural wetland (chi-square, $p < 0.001$) (Table 1). The next highest observation times were the domesticated cat and the domesticated dog in the urban wetland (27% and 15%, respectively) and the white-tailed deer, *Odocoileus virginianus*, in the rural wetland (27%). Humans accounted for 11% of the urban wetland activity (Table 2).

Average light illumination between sites differed as much as 2.0 lumens/m^2 from 1900 h to 2030 h and $5.0 \times 10^{-5} \text{ lumens/m}^2$ from 2100 h to 2330 h (Figure 1) with significant ($p < 0.05$) higher illumination levels in the urban wetland from 2000 h to 2200 h. Average decibel levels between sites are shown in Figure 2. The urban wetland

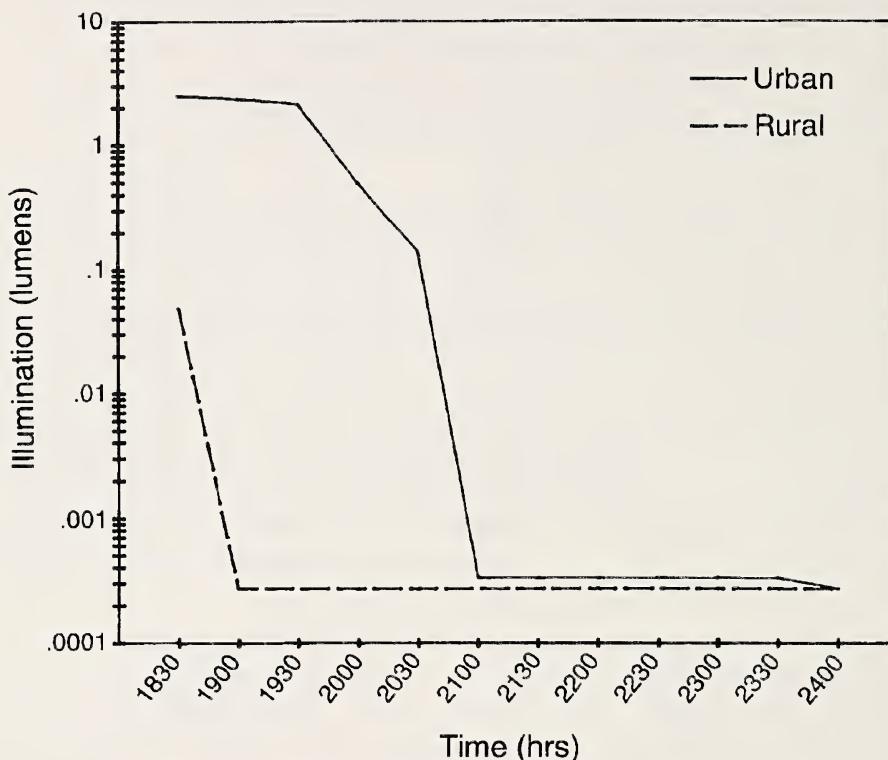


FIGURE 1. Average illumination between urban and rural sites from 1830 to 2400.

had average decibel levels at least 18 units higher than the rural wetland and peaks of as high as 90 decibels. Decibel levels in the rural wetland never exceeded the minimum for the instrument at 50 decibels.

Four predators were observed in this study, domesticated dog, domesticated cat, human, and barred owl, *Strix varia*. The dog, cat and human were observed in the urban wetland with the human and dog activity occurring during the early evening under higher light illumination and the cat activity occurring closer to midnight under lower light illumination. The predator observed in the rural wetland was the barred owl.

DISCUSSION

The increase in bat activity in the urban versus the rural wetland may be the result of the higher light illumination levels in the urban wetland from street and porch lights and the subsequent increase in flying insect activity. The absence of deer from the urban wetland may be attributable to the presence of humans and their pets, the higher light levels, and the absence of a forested buffer. The absence owls from the urban wetland may be attributable to a lack of prey resulting from an avoidance of the area by rodents due to increased light levels and predation by cats. Heteromyid rodents

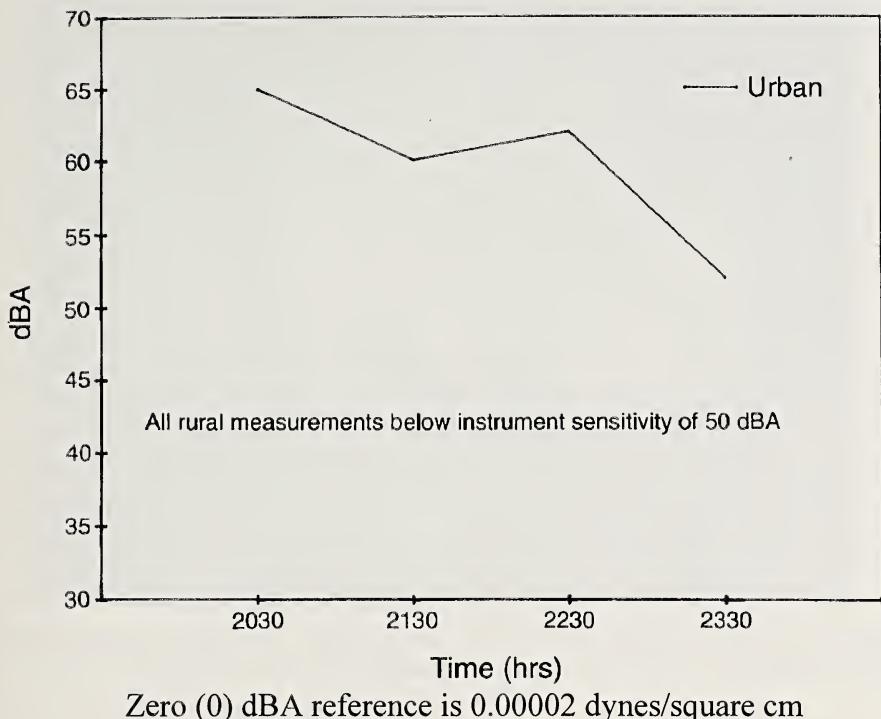


FIGURE 2. Maximum noise levels in decibels (dBA) between urban and rural sites

have been shown to reduce feeding activity under increased illumination (Brown et al., 1988; Wolfe et al., 1989; Daly et al., 1992). The differences in light illumination between the urban and rural wetland sites ranged from 2.432 lumens/m² at dusk to 6.0×10^{-5} lumens/m² just before midnight. An illumination increase of 2.0×10^{-6} lumens/m² was shown to considerably increase an owl's ability to locate prey (Dice, 1945). Similarly, Clarke (1983) noted an increase in owl hunting efficiency with increasing moonlight illumination. Domesticated cats have been shown to be major predators of birds and mammals and it is suggested that a cat's urge to hunt is independent of the urge to eat (Haspel and Calhoon, 1993).

Noise levels in the urban surrounded wetland were noticeably higher than in the rural or forest surrounded wetland. The urban surrounded wetland showed average noise levels that ranged from that typical of a quiet automobile of around 50 decibels to slightly less than that typical of busy street traffic of around 70 decibels. Decibel peaks in the urban wetland of up to 90 decibels occurred periodically throughout the sample period coinciding with noise associated with sirens, horns, barking dogs, slamming doors, and a train. The rural wetland site had decibels levels lower than the sensitivity of the sound level recorder and never exceeded the minimum level of 50 decibels. A more sensitive recorder that can be adjusted to lower intensities and higher frequencies (20,000 - 50,000 Hz) should be used to more accurately investigate noise levels that are within most animal hearing but beyond human sensitivity. Ancillary



FIGURE 3. Deer photographed under three-quarter moon illumination at 25 meters using 3200 speed film and a 35mm camera equipped with a 3x image intensifier lens. (Photo by W. I. Priest).

information such as small mammal population densities would significantly enhance conclusions regarding predator use of these areas. High decibel levels, high nighttime illumination, reduction in upland forest buffer, and the presence of domesticated pets could reduce the attractiveness of a site as habitat for certain reclusive animals and more intensive investigation using replicate sites should be conducted.

The use of night-vision equipment has significant potential for the concealed observation of medium to large nocturnal animals. The methodology used in this study can be improved by limiting the study times to early spring before leaf-out or late autumn after leaf-fall to eliminate interference due to dense foliage. Better observation would be obtained by establishing elevated observation platforms. Inexpensive infrared light sources can be constructed using infrared diodes and nine-volt batteries. These can be placed throughout the study site to illuminate the observation area and increase visibility through the image intensifier equipment. Cameras can be outfitted with image intensifier lenses to allow photography of nocturnal animal activity (Figure 3). Video cameras outfitted with image intensifier lenses can be stationed on site and the signal transmitted to a remote location for real time, off site viewing and recording. The primary author is presently investigating the use of night-vision video cameras randomly distributed within a study area that, with the use of lithium batteries and solar cells, can remain on site for weeks or months (Havens and Sharp, 1995).

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An Update of Raney's 1950 Account of Freshwater Fishes of the James River Basin

Eugene G. Maurakis and William S. Woolcott

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ABSTRACT

Objectives are to provide a current list (and prevailing nomenclature) of freshwater fishes in the James River basin, and update discussions on the origin and relationships of the James River ichthyofauna, and the distributions of fishes within the system. The James River drainage contains 108 freshwater species (59 genera) in 21 families of fishes (81 native and 27 introduced species), including three endemics, two species (*Notropis semperasper* and *Etheostoma longimanum*), and one subspecies (*Percina notogramma montuosa*). The Piedmont contains the highest number (85) of species followed by Coastal Plain (75) and Montane (67). The high number of native species in the James River is attributed to acquisition of species from different origins and by different mechanisms. Phylogenetic relationships of native fishes by family are required to test earlier hypotheses that the James River drainage is more closely related to northern drainages (i.e., York and northward) than to southern ones (i.e., Roanoke and southward).

INTRODUCTION

It is apropos at this time to furnish a revision of Raney's (1950) list of freshwater fishes from the James River as the Science Museum of Virginia is designing the *Hirschler Aquarium*, an exhibition featuring the freshwater fishes of the James River. Edward C. Raney presented an annotated list of freshwater fishes from the James River basin in *The James River: Past, Present, and Future* published by the Virginia Journal of Science in 1950. His report, first to assemble all known information on freshwater fishes in the James River, relied heavily on collections of Cope (1869) and Jordan (1890), as "no systematic survey has ever been made of the fish fauna of the James River nor of any of the rivers in Virginia." Raney stated distributions of the original fish fauna probably never will be known as the river has suffered from the effects of industrial and domestic pollution." Since 1950, the river has continued to experience alterations related to anthropogenic and natural perturbations (e.g. kepone, and two 100-year floods, Camille in 1969 and Agnes in 1972)(Woolcott, 1974).

Significant ecological projects of freshwater fishes since Raney's account include a treatise on the aquatic ecosystem of the Piedmont section of the James River by Woolcott (1974); fish community studies of the mainstem James River by Garman et al. (1991); and a book on freshwater fishes of Virginia by Jenkins and Burkhead (1994). However, as none specifically compared current freshwater fish fauna in the James to that reported by Raney (1950), our objectives are to provide a current list (and prevailing nomenclature) of freshwater fishes in the James River basin, and an update on the origin and relationships of the James River ichthyofauna, and the distributions of fishes within the system.

MATERIALS AND METHODS

Occurrence and distributional data of James River fishes are derived from Hocutt and Wiley (1986), Garman et al. (1991), Jenkins and Burkhead (1994), and the Virginia Department of Game and Inland Fisheries. Nomenclature is consistent with that in Jenkins and Burkhead (1994) where nomenclatural synonymy follows the rules of the International Code of Zoological Nomenclature (ICZN, 1985).

We use the following physiographic designations to conform to Raney's physiographic designations (Montane, Piedmont, and Coastal Plain) for the river and to delineate the course of the James River: Montane (includes Appalachian Plateau, Valley, and Blue Ridge); Piedmont (from Blue Ridge to Fall Line); and Coastal Plain (from Fall Line to mouth in Chesapeake Bay). Species status designations (E=endemic; I=introduced; IP=introduced, but possibly native; Ma=marine or estuarine with native freshwater occurrence; N=native; and NI, regarded as native, but possibly introduced) follow Jenkins and Burkhead (1994).

RESULTS AND DISCUSSION

James River Freshwater Fishes - The James River drainage contains 108 freshwater species (59 genera) in 21 families of fishes (81 native and 27 introduced species), including three endemics, two species (*Notropis semperasper* and *Etheostoma longimanum*), and one subspecies (*Percina notogramma montuosa*)(Table 1). Approximately 70 % of all species are in five families (Cyprinidae, 27.8 %; Centrarchidae, 14.8 %; Percidae, 11.1 %; Ictaluridae, 9.3 %; and Catostomidae, 7.4 %)(Table 1). Nine families are represented each by one species.

We concur with Jenkins and Burkhead (1994) that *Menedia beryllina*, *Fundulus heteroclitus* and *Apeltes quadratus*, which are listed in Raney's account (1950), are estuarine forms, and are not included in the total count. *Gasterosteus aculeatus*, an estuarine form which may spawn in freshwater (Jenkins and Burkhead, 1994), is included in our total count of freshwater fishes.

Of the 14 species [*Lampetra aepyptera*, *Acipenser brevirostris*, *Salmo trutta* (I), *Oncorhynchus mykiss*(=*Salmo gairdnerii* in Raney, 1950; I), *Carpiodes cyprinus*, *Erimyzon suetta suetta*, *Moxostoma macrolepidotum*, *Cyprinus carpio* (I), *Carassius auratus* (I), *Notropis chalybaeus*, *Perca flavescens*, *Lepomis cyanellus* (I), *Enneacanthus chaetodon* (=*Mesogonitsius chaetodon* in Raney, 1950), and *Pomoxis annularis* (I)] Raney (1950) lists that "probably will be found in the drainage when an exhaustive survey is made," all but three [*Acipenser brevirostrum* (=*Acipenser brevirostris* in Raney, 1950), *Erimyzon suetta*, and *Enneacanthus chaetodon* *chaetodon*] occur in the drainage. *Acipenser brevirostrum* is known only from the Potomac River in Virginia; and *E. suetta* and *E. chaetodon* from the Chowan River (Roanoke River drainage). However, six native species (*Lampetra appendix*, *Nocomis raneyi*, *Notropis bifrenatus*, *Notropis semperasper*, *Moxostoma erythrurum*, and *Etheostoma serrifer*), which are not listed in Raney (1950), have been identified in the James drainage since his account. Thirteen species have been introduced in the James drainage since Raney's publication (1950): *Dorosoma petenense*, *Esox lucius*, *Esox masquinongy*, *Ctenopharyngodon idella*, *Notropis telescopus*, *Pimephales notatus*, *Ictalurus furcatus*, *Noturus gilberti*, *Polydactylus olivaris*, *Morone chrysops*, *Lepomis microlophus*, *Percina roanoka*, and *Stizostedion vitreum*.

TABLE 1. Comparison of the freshwater fish fauna of the James River drainage in 1996 to that in Raney (1950). Nomenclature and species status designations (E=endemic; I=introduced; IP=introduced, but possibly native; Ma=marine or estuarine with native freshwater occurrence; N=native; NI, regarded as native, but possibly introduced) follow Jenkins and Burkhead (1994). Occurrence of a species in the James River drainage in Raney (1950) is indicated by an X.

	1996	1950	
Petromyzontidae			Petromyzonidae
<i>Lampetra aepyptera</i>	N	-	
<i>Lampetra appendix</i>	N	-	
<i>Petromyzon marinus</i>	Ma	X	
Acipenseridae			
<i>Acipenser o. oxyrinchus</i>	Ma	X	<i>Acipenser sturio oxyrinchus</i>
Lepisosteidae			
<i>Lepisosteus osseus</i>	N	X	<i>Lepisosteus osseus osseus</i>
Amiidae			
<i>Amia calva</i>	N	X	
Anguillidae			
<i>Anguilla rostrata</i>	Ma	X	<i>Anguilla bostoniensis</i>
Clupeidae			
<i>Alosa aestivalis</i>	Ma	X	<i>Pomolobus aestivalis</i>
<i>Alosa mediocris</i>	Ma	-	
<i>Alosa pseudoharengus</i>	Ma	X	<i>Pomolobus pseudoharengus</i>
<i>Alosa sapidissima</i>	Ma	X	
<i>Dorosoma cepedianum</i>	N	X	
<i>Dorosoma petenense</i>	I	-	
Esocidae			
<i>Esox a. americanus</i>	N	X	<i>Esox americanus</i>
<i>Esox lucius</i>	I	-	
<i>Esox masquinongy</i>	I	-	
<i>Esox niger</i>	N	X	
Umbridae			
<i>Umbr a. pygmaea</i>	N	X	
Cyprinidae			
<i>Campostoma anomalum michauxi</i>	N	X	<i>Campostoma anomalum</i> subsp.
<i>Carassius auratus</i>	I	-	
<i>Clinostomus f. funduloides</i>	N	X	<i>Clinostomus vandoisulus</i>
<i>Ctenopharyngodon idella</i>	I	-	
<i>Cyprinella analostana</i>	N	X	<i>Notropis analostanus</i>
<i>Cyprinus carpio</i>	I	-	
<i>Exoglossum maxillingua</i>	N	X	
<i>Hybognathus regius</i>	N	X	<i>Hybognathus nuchalis regius</i>
<i>Luxilus cerasinus</i>	IP	-	
<i>Luxilus cornutus</i>	N	X	<i>Notropis cornutus cornutus</i>
<i>Lythrurus a. ardens</i>	N	X	<i>Notropis a. ardens</i>
<i>Nocomis l. leptocephalus</i>	N	X	<i>Margariscus margarita margarita</i>
<i>Nocomis micropogon</i>	N	X	<i>Nocomis leptocephalus</i>
<i>Nocomis raneyi</i>	NI	-	
<i>Notemigonus crysoleucus</i>	N	X	<i>Notemigonus crysoleucus crysoleucus</i>
<i>Notropis amoena</i>	N	X	
<i>Notropis bifrenatus</i>	N	-	

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TABLE 1. *continued.*

<i>Notropis chalybaeus</i>	N	-	
<i>Notropis hudsonius</i>	N	X	<i>Notropis hudsonius saludanus</i>
<i>Notropis p. procne</i>	N	X	<i>Notropis procne procne</i>
<i>Notropis r. rubellus</i>	N	X	<i>Notropis rubellus</i>
<i>Notropis semperasper</i>	E	-	
<i>Notropis telescopus</i>	IP	-	
<i>Notropis volucellus</i>	NI	-	
<i>Phoxinus oreas</i>	N	X	<i>Chrosomus oreas</i>
<i>Pimephales notatus</i>	IP	-	<i>Hyborhynchus notatus</i>
<i>Rhinichthys a. atratulus</i>	N	X	
<i>Rhinichthys cataractae</i>	N	X	
<i>Semotilus atromaculatus</i>	N	X	<i>Semotilus atromaculatus atromaculatus</i>
<i>Semotilus corporalis</i>	N	X	<i>Leucosomus corporalis</i>
Catostomidae			
<i>Carpioles c. cyprinus</i>	N	-	
<i>Catostomus commersoni</i>	N	X	<i>Catostomus commersonii commersonii</i>
<i>Erimyzon o. oblongus</i>	N	X	
<i>Hypentelium nigricans</i>	N	X	
<i>Moxostoma erythrurum</i>	N	-	
<i>Moxostoma m. macrolepidotum</i>	N	-	
<i>Scartomyzon cervinus</i>	IP	-	
<i>Thoburnia rhothoeca</i>	N	X	
Ictaluridae			
<i>Ameiurus catus</i>	N	X	
<i>Ameiurus natalis</i>	N	X	<i>Ameiurus natalis erebennus</i>
<i>Ameiurus nebulosus</i>	N	X	<i>Ameiurus nebulosus nebulosus</i>
<i>Ameiurus platycephalus</i>	NI	-	
<i>Ictalurus furcatus</i>	I	-	
<i>Ictalurus punctatus</i>	I	X	<i>Ictalurus lacustris punctatus</i>
<i>Noturus giberti</i>	IP	-	
<i>Noturus gyrinus</i>	N	X	<i>Schilbeodes mollis</i>
<i>Noturus insignis</i>	N	X	<i>Schilbeodes marginatus marginatus</i>
<i>Polydictis olivaris</i>	I	-	
Salmonidae			
<i>Oncorhynchus mykiss</i>	I	X	<i>Salmo gairdneri</i>
<i>Salmo trutta</i>	I	-	
<i>Salvelinus fontinalis</i>	N	X	<i>Salvelinus fontinalis fontinalis</i>
Aphredoderidae			
<i>Aphredoderus s. sayanus</i>	N	X	
Amblyopsidae			
<i>Chologaster cornuta</i>	N	X	<i>Chlogaster cornutus</i>
Fundulidae			
<i>Fundulus d. diaphanus</i>	Ma	X	
<i>Fundulus lineolatus</i>	N	-	
Poeciliidae			
<i>Gambusia holbrooki</i>	N	X	<i>Gambusia affinis holbrookii</i>
Gasterosteidae			
<i>Gasterosteus aculeatus</i>	N	-	
Cottidae			
<i>Cottus b. bairdi</i>	N	X	<i>Cottus bairdii bairdii</i>
<i>Cottus girardi</i>	NI	-	
-	X	-	<i>Cottus cognatus gracilis</i>

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TABLE 1. *continued*

Moronidae			Serranidae	
<i>Morone americana</i>	Ma	X		
<i>Morone chrysops</i>	I	-		
<i>Morone saxatilis</i>	Ma	X	<i>Roccus saxatilis</i>	
Centrarchidae				
<i>Acantharchus pomotis</i>	N	X		
<i>Ambloplites rupestris</i>	I	X	<i>Ambloplites rupestris rupestris</i>	
<i>Centrarchus macropterus</i>	N	X		
<i>Enneacanthus gloriosus</i>	N	X		
<i>Enneacanthus obesus</i>	N	X		
<i>Lepomis auritus</i>	N	X		
<i>Lepomis cyanellus</i>	I	-		
<i>Lepomis gibbosus</i>	N	X		
<i>Lepomis gulosus</i>	NI	X	<i>Chaenobrytus coronarius</i>	
<i>Lepomis macrochirus</i>	I	X	<i>Lepomis macrochirus macrochirus</i>	
<i>Lepomis microlophus</i>	I	-		
<i>Micropterus dolomieu</i>	I	X	<i>Micropterus dolomieu dolomieu</i>	
<i>Micropterus punctulatus</i>	I	-		
<i>Micropterus salmoides</i>	IP	X	<i>Micropterus salmoides salmoides</i>	
<i>Pomoxis annularis</i>	I	-		
<i>Pomoxis nigromaculatus</i>	N	X	<i>Pomoxis nigro-maculatus</i>	
Percidae				
<i>Etheostoma flabellare humerale</i>	N	X	<i>Poecilichthys flabellaris</i>	
<i>Etheostoma f. fusiforme</i>	N	X	<i>Hololepis fusiformis</i>	
<i>Etheostoma longimanum</i>	E	X	<i>Boleosoma longimanum</i>	
<i>Etheostoma n. nigrum</i>	N	X	<i>Boleosoma nigrum</i> subsp.	
<i>Etheostoma o. olmstedi</i>	N	-		
<i>Etheostoma o. atramaculatum</i>	N	X	<i>Boleosoma nigrum olmstedi</i>	
<i>Etheostoma serrifer</i>	N	-		
<i>Etheostoma vitreum</i>	N	X	<i>Ioa vitrea</i>	
<i>Perca flavescens</i>	N	-		
<i>Percina n. notogramma</i>	N	X	<i>Hadropterus notogrammus</i>	
<i>Percina n. montuosa</i>	E	-		
<i>Percina peltata</i>	N	X	<i>Hadropterus peltatus peltatus</i>	
<i>Percina roanoka</i>	IP	-		
<i>Stizostedion vitreum</i>	I	-		

Two species [*Margariscus margarita* and *Cottus (cognatus) gracilis*, natives of the Potomac River], which Raney (1950) reports to be in the James River, do not occur in the drainage.

Raney (1950) states that eight fishes [*Notropis atherinoides*, *Luxilus cerasinus* (=*Notropis cerasinus*), *Notropis procne longiceps*, *Notropis macdonaldi*, *Scartomyzon cervinus* (=*Moxomstoma cervinum*), *Percina crassa* (=*Hadropterus crassus*), *Boleosoma nigrum effulgens*, and *Boleosoma podostemone*] have been reported erroneously from the James; however, two, *Scartomyzon cervinus* (IP) and *Luxilus cerasinus* (IP) have been found in the drainage since his account. *Percina crassa* of Raney (1950) probably was *Percina roanoka*, which was elevated to species status by Mayden

and Page (1979) who concluded it was specifically different from *P. crassa* in the Cape Fear, Peedee and Santee river drainages.

Origin and Relationships of the James River Freshwater Ichthyofauna - We agree with Jenkins and Burkhead (1994) and Hocutt and Wiley (1986), who, like Raney (1950), attribute the high number of native species in the James River to acquisition of species from different origins [i.e., southern Coastal Plain, Roanoke drainage, New-Ohio drainage (Teays River), Susquehanna drainage, and from speciation events within the drainage], and by different mechanisms (i.e., stream capture, including subterranean connections; extended rivers; and estuarine flooding). Jenkins and Burkhead (1994) state five species (*Chologaster cornuta*, *Fundulus lineolatus*, *Pomoxis nigromaculatus*, *Lepomis gulosus*, and *Etheostoma serrifer*) have the northern part of their Atlantic Coast range in the James. Eight taxa terminate their southern Atlantic Coast range in the James: *Rhinichthys cataactae*, *Semotilus corporalis*, *Nothonotus micropogon*, *Luxilus cornutus*, *Notropis rubellus*, *Notropis p. procne*, *Percina n. notogramma*, and *Percina p. peltata*) (Jenkins and Burkhead, 1994). We do not recognize the subspecies *P. p. peltata*, having resurrected *Percina peltata nevisense*, in the Roanoke, Chowan, Tar and Neuse river systems, to specific status, *Percina nevisense* (Goodin et al., In review). According to Jenkins and Burkhead (1994), eight upland species end their northern range in the James: *Rhinichthys atratulus obtusus*, *Campostoma anomalum michauxi*, *Nothonotus raneyi*, *Lythrurus ardens*, *Notropis volucellus*, *Moxostoma erythrurum*, *Ameiurus platycephalus*, and *Etheostoma nigrum*). Jenkins and Burkhead (1994) regard occurrences of *R. a. obtusus*, *Fundulus diaphanus*, and *Cottus girardi* in the upper James drainage a result of faunal transfer via subterranean connections.

Based on similarity indices (phenetic methods), Jenkins and Burkhead (1994) and Hocutt and Wiley (1986) concur with Raney (1950) that the James ichthyofauna is more similar to those of the York, Rappahannock, and Potomac drainages than to the Chowan and Roanoke faunas in the south. However, many biogeographic and systematics studies have demonstrated that the underlying concept of overall similarity in phenetic methods is unlikely to reveal historical patterns, as no distinction is made between shared ancient events and shared recent events (Nelson and Platnick, 1981; Patterson, 1983). Rather than a phenetic approach, Maurakis and Lipscomb (1995) used phylogenetic methodologies to examine historical relationships of 19 Atlantic Slope river drainages in North America. With species of Cyprinidae, they hypothesized mid-Atlantic rivers form a monophyletic group, which is subdivided into two distinct assemblages (1) Susquehanna, Delaware, Potomac, and Rappahannock and (2) York, James, Roanoke, Tar and Neuse (Fig. 1). Their results suggest the James River cyprinid fauna is related more closely to southern drainages than to more northern ones. However, Maurakis and Lipscomb (1995) found that Catostomidae in the James River is related more closely to northern drainages (Fig. 2), a result comparable to that of Hocutt and Wiley (1986). Maurakis and Lipscomb (1995) state that phylogenetic relationships of native fishes are required to test these hypotheses as evolutionary relatedness of organisms indicates the degree of kinships among drainages. For example, if the Roanoke and James Rivers are historically related (Holt, 1972; Hocutt and Wiley, 1986), then they should contain evolutionary related fishes as indicated by a cladogram of species (Fig. 1).

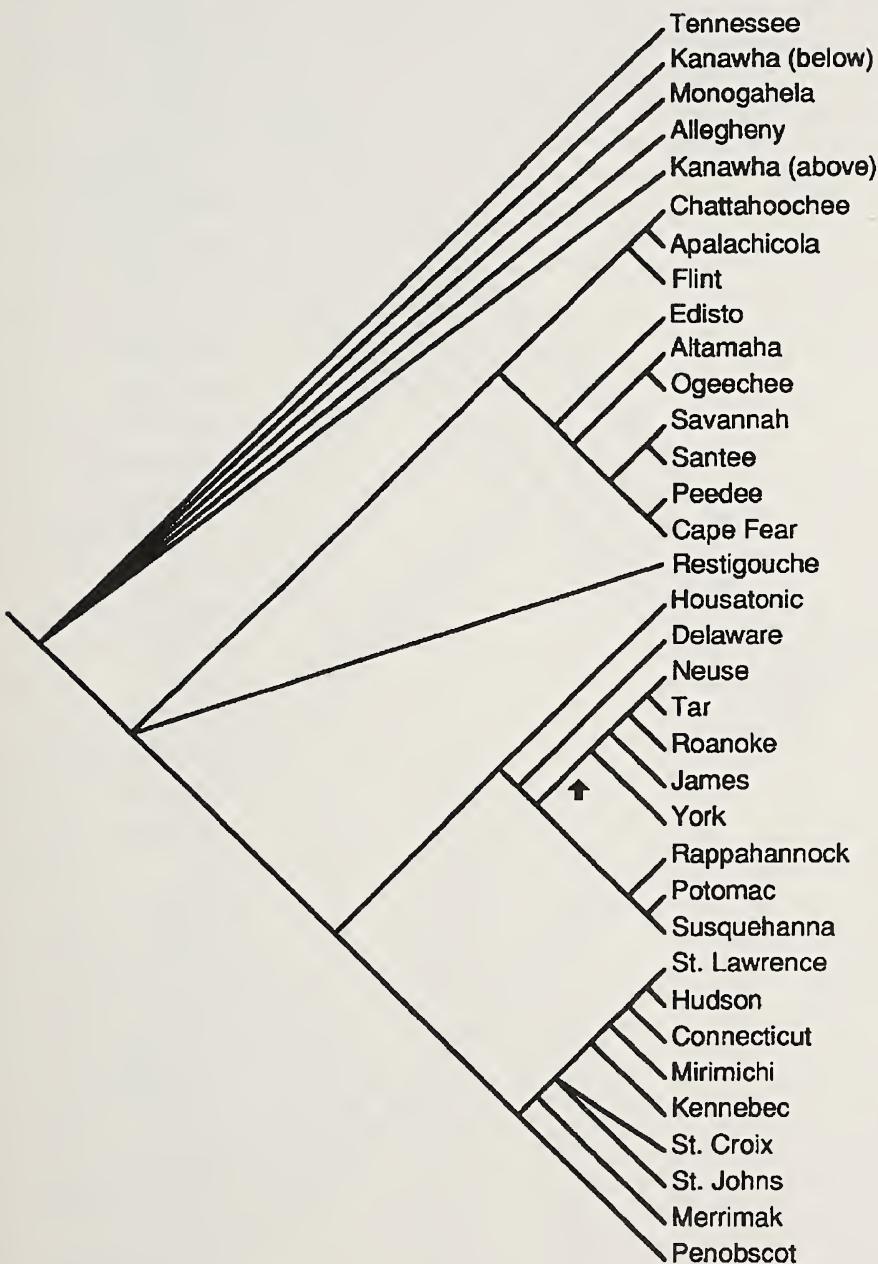


FIGURE 1. Historical relationships of Atlantic Slope drainages based on distributions of Cyprinidae (Redrawn from Maurakis and Lipscomb, 1995).

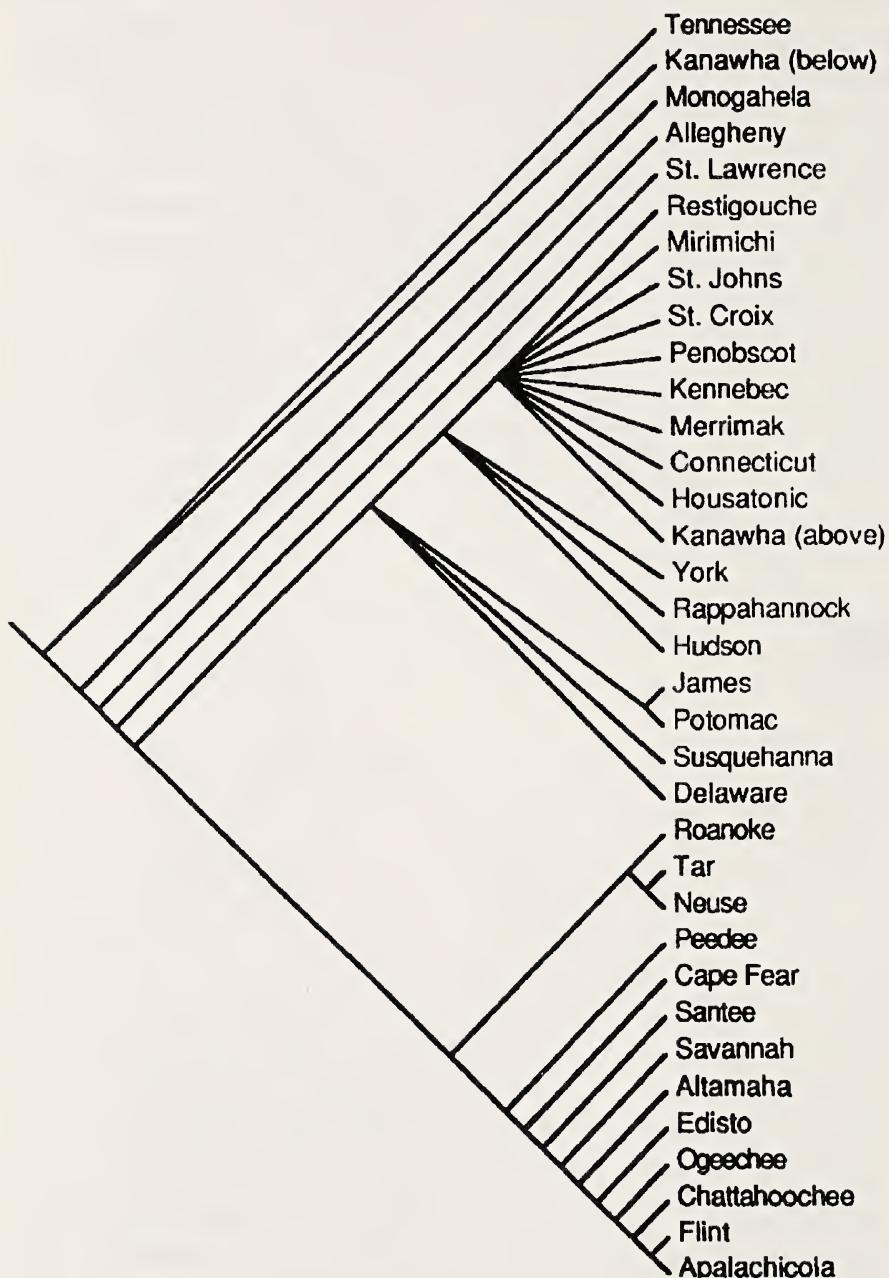


FIGURE 2. Historical relationships of Atlantic Slope drainages based on distributions of Catostomidae (Redrawn from Maurakis and Lipscomb, 1995).

TABLE 2. Distribution of freshwater fishes in the James River drainage in 1996 by physiographic province (Montane, including Blue Ridge, Valley, and Plateau; Piedmont; and Coastal Plain).

Taxon	Physiographic Province		
	Montane	Piedmont	Coastal Plain
Petromyzontidae			
<i>Lampetra aepyptera</i>	-	-	x
<i>Lampetra appendix</i>	-	-	x
<i>Petromyzon marinus</i>	-	-	x
Acipenseridae			
<i>Acipenser oxyrinchus</i>	-	-	x
Lepisosteidae			
<i>Lepisosteus osseus</i>	x	x	x
Amiidae			
<i>Amia calva</i>	-	-	x
Anguillidae			
<i>Anguilla rostrata</i>	x	x	x
Clupeidae			
<i>Alosa aestivalis</i>	-	x	x
<i>Alosa mediocris</i>	-		x
<i>Alosa pseudoharengus</i>	-	x	x
<i>Alosa sapidissima</i>	-	x	x
<i>Dorosoma cepedianum</i>	-	x	x
<i>Dorosoma petenense</i>	-	x	x
Esocidae			
<i>Esox a. americanus</i>	-	-	x
<i>Esox lucius</i>	-	x	x
<i>Esox masquinongy</i>	-	x	x
<i>Esox niger</i>	x	x	x
Umbridae			
<i>Umbrä pygmaea</i>	-	x	x
Cyprinidae			
<i>Campostoma anomalum</i>	x	x	-
<i>Carassius auratus</i>	-	x	x
<i>Clinostomus funduloides</i>	x	x	x
<i>Ctenopharyngodon idella</i>	x	x	-
<i>Cyprinella analostana</i>	x	x	x
<i>Cyprinus carpio</i>	x	x	x
<i>Exoglossum maxillingua</i>	x	x	-
<i>Hybognathus regius</i>	x	x	x
<i>Luxilus cerasinus</i>	x	x	-
<i>Luxilus cornutus</i>	x	x	x
<i>Lythrurus ardens</i>	x	x	-
<i>Nocomis leptcephalus</i>	x	x	x
<i>Nocomis micropogon</i>	x	x	-
<i>Nocomis raneyi</i>	x	x	x
<i>Notemigonus crysoleucas</i>	x	x	x
<i>Notropis amoenus</i>	x	x	-
<i>Notropis bifrenatus</i>	-	x	x
<i>Notropis chalybaeus</i>	-	-	x
<i>Notropis hudsonius</i>	x	x	x
<i>Notropis p. procne</i>	x	x	x
<i>Notropis r. rubellus</i>	x	x	-

continued on next page

TABLE 2. *continued*

Taxon	Physiographic Province		
	Montane	Piedmont	Coastal Plain
<i>Notropis semperasper</i>	x	-	-
<i>Notropis telecopus</i>	x	-	-
<i>Notropis volucellus</i>	x	-	-
<i>Phoxinus oreas</i>	x	x	-
<i>Pimephales notatus</i>	x	x	-
<i>Rhinichthys atratulus</i> (2)	x	x	-
<i>Rhinichthys cataractae</i>	x	x	-
<i>Semotilus atromaculatus</i>	x	x	x
<i>Semotilus corporalis</i>	x	x	x
Catostomidae			
<i>Carpioles cyprinus</i>	x	x	x
<i>Catostomus commersoni</i>	x	x	-
<i>Erimyzon o. oblongus</i>	x	x	x
<i>Hypentelium nigricans</i>	x	x	-
<i>Moxostoma erythrurum</i>	x	x	-
<i>Moxostoma m. macrolepidotum</i>	x	x	x
<i>Scartomyzon cervinus</i>	x	x	-
<i>Thoburnia rhothoeca</i>	x	x	-
Ictaluridae			
<i>Ameiurus catus</i>	x	x	x
<i>Ameiurus natalis</i>	x	x	x
<i>Ameiurus nebulosus</i>	x	x	x
<i>Ameiurus platycephalus</i>	x	-	-
<i>Ictalurus furcatus</i>	-	-	x
<i>Ictalurus punctatus</i>	x	x	x
<i>Noturus gilberti</i>	x	-	-
<i>Noturus gyrinus</i>	-	x	x
<i>Noturus insignis</i>	x	x	x
<i>Polydactylus olivaris</i>	x	-	x
Salmonidae			
<i>Oncorhynchus mykiss</i>	x	x	-
<i>Salmo trutta</i>	x	-	-
<i>Salvelinus fontinalis</i>	x	x	-
Aphredoderidae			
<i>Aphredoderus sayanus</i>	-	x	x
Amblyopsidae			
<i>Chologaster cornuta</i>	-	-	x
Fundulidae			
<i>Fundulus diaphanus</i>	x	-	x
<i>Fundulus lineolatus</i>	-	-	x
Poeciliidae			
<i>Gambusia holbrookii</i>	-	x	x
Gasterosteidae			
<i>Gasterosteus aculeatus</i>	-	-	x
Cottidae			
<i>Cottus bairdi</i>	x	x	-
<i>Cottus girardi</i>	x	-	-

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TABLE 2. *continued*

Taxon	Physiographic Province		
	Montane	Piedmont	Coastal Plain
Moronidae			
<i>Morone americana</i>	-	x	x
<i>Morone chrysops</i>	-	x	-
<i>Morone saxatilis</i>	-	x	x
Centrarchidae			
<i>Acantharchus pomotis</i>	-	x	x
<i>Ambloplites rupestris</i>	x	x	x
<i>Centrarchus macropterus</i>	-	x	x
<i>Enneacanthus gloriosus</i>	-	x	x
<i>Enneacanthus obesus</i>	-	-	x
<i>Lepomis auritus</i>	x	x	x
<i>Lepomis cyanellus</i>	x	x	x
<i>Lepomis gibbosus</i>	x	x	x
<i>Lepomis gulosus</i>	-	x	x
<i>Lepomis macrochirus</i>	x	x	x
<i>Lepomis microlophus</i>	-	x	x
<i>Micropterus dolomieu</i>	x	x	x
<i>Micropterus punctulatus</i>	-	x	-
<i>Micropterus salmoides</i>	x	x	x
<i>Pomoxis annularis</i>	-	x	x
<i>Pomoxis nigromaculatus</i>	x	x	x
Percidae			
<i>Etheostoma flabellare</i>	x	x	x
<i>Etheostoma fusiforme</i>	-	x	x
<i>Etheostoma longimanum</i>	x	x	-
<i>Etheostoma nigrum</i>	x	x	-
<i>Etheostoma olmstedi</i> (2)	-	x	x
<i>Etheostoma serrifer</i>	-		x
<i>Etheostoma vitreum</i>	-	x	x
<i>Perca flavescens</i>	x	x	x
<i>Percina notogramma</i> (2)	x	x	-
<i>Percina peltata</i>	x	x	x
<i>Percina roanoka</i>	x	x	-
<i>Stizostedion vitreum</i>	-	x	x
Total species/physiographic region	67	85	75
Total species limited/physiographic region	7	2	14

Distribution of Fishes Within the System - The Piedmont James River contains 85 species, the Montane 67, and the Coastal Plain 75 (Table 2). Within the drainage, 14 species are limited to the Coastal Plain (*Lampetra aepyptera*, *Lampetra appendix*, *Petromyzon marinus*, *Acipenser oxyrinchus*, *Amia calva*, *Alosa mediocris*, *Esox a. americanus*, *Notropis chalybaeus*, *Ictalurus furcatus*, *Chologaster cornuta*, *Fundulus lineolatus*, *G. aculeatus*, *Enneacanthus obesus*, and *Etheostoma serrifer*). Seven species (*Notropis semperasper*, *Notropis telescopus*, *Notropis volucellus*, *Ameiurus platycephalus*, *Noturus giberti*, *Salmo trutta*, and *Cottus girardi*) are limited to the Montane region. Two species (*Morone chrysops* and *Micropterus punctulatus*) are limited to the Piedmont (Table 2). Twenty-four species are shared between Montane and Piedmont regions, and 25 are shared between the Piedmont and Coastal Plain (Table 2). Two species, *Fundulus diaphanus* and *Pylodictus olivaris*, occur in Montane and Coastal Plain regions. Thirty-four species occur in all three physiographic regions.

ACKNOWLEDGEMENTS

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Do Striped Bass and Blue Crab Abundances Correlate in Chesapeake Bay?

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ABSTRACT

We examined a corollary to the hypothesis that striped bass regulate the blue crab population in Chesapeake Bay by preying on juveniles, an expected inverse correlation between striped bass and blue crab abundance. Abundance indices based on Virginia striped bass young-of-the-year beach seine data (1980-1992) were constructed for fish ages 1 - 8, and for the Virginia resident stock component, ages 1 - 5. Fishery-independent, pound net data for fall and spring were also used to construct indices of striped bass abundance in Rappahannock River (1986-1993). Juvenile blue crab abundance indices were constructed based on trawl survey data from the James, York and Rappahannock Rivers. Fall crab abundance correlated positively with predicted Virginia resident striped bass abundance. Crab abundance in the spring did not correlate with any measure of striped bass abundance, nor did fall Rappahannock River crab abundance correlate with the fall Rappahannock River pound net index. Thus, these data do not support the hypothesis that striped bass abundance and blue crab abundance are inversely related. Striped bass populations do not appear to have regulated blue crab population dynamics in the Virginia portion of Chesapeake Bay from 1980 to 1992.

Key words: Chesapeake Bay, striped bass, blue crabs, population regulation, predation

INTRODUCTION

The Chesapeake Bay striped bass (*Morone saxatilis*) stock has made a substantial recovery in recent years, possibly due in part to aggressive management on the part of interstate and state agencies. Concurrently, Chesapeake Bay blue crab (*Callinectes sapidus*) abundance and harvests have been relatively low. Commercial fishermen have suggested that striped bass are depleting the blue crab populations in the Chesapeake Bay. However, only a few attempts have been made to examine this influence (Goshorn and Casey, 1993).

We analysed available data to test the hypothesis that striped bass abundance and juvenile blue crab abundance are inversely related in the Virginia portion of Chesapeake Bay.

METHODS

A model predicting relative abundance of resident Chesapeake Bay striped bass was constructed using the Virginia portion of the Virginia Institute of Marine Science (VIMS) weighted, Chesapeake Bay-wide, juvenile striped bass index (Austin et al.,

1993) (Table 1). This index is based upon the VIMS beach seine survey, in which fixed stations on the James, York and Rappahannock River systems are sampled three times each summer, from July through September. The striped bass juvenile index is a weighted geometric mean of the number of juvenile bass per haul, calculated as

$$\bar{x} = \sum_{k=1}^3 \left[\log^{-1} \left[\left[\frac{\sum_{i=1}^{n_k} \log(x_{ik} + 1)}{n_k} \right] - 1 \right] w t_k \right], \quad [\text{Equ. 1}]$$

where $k = 1$ = James River, $2 =$ York River and $3 =$ Rappahannock River. The weighting factor $w t_k$ is calculated from the nursery ground surface area for the respective rivers, and n_k is the number of times the k^{th} river system was visited in a particular year (Austin et al., 1993).

Survival of each year class was calculated for each year t using the expression

$$N_t = N_{t-1} e^{-Z_t}, \quad [\text{Equ. 2}]$$

where total mortality Z is given by:

$$Z = M + F, \quad [\text{Equ. 2a}]$$

if fish are recruited to the fishery, and

$$Z = M + C * F, \quad [\text{Equ. 2b}]$$

otherwise, where $C * F$ ($C = 0.20$) is an estimate of poaching and hook-and-release mortalities (Rugolo, pers. comm.¹). Here $M = 0.20$ is the commonly used value for natural mortality (Lackey and Nielsen, 1980), and F is historical fishing mortality by year (1959-1984: Gibson, 1993; 1985-1992: Rugolo, pers. comm.). The interval 1980-1992 was chosen as these are the years for which uninterrupted VIMS beach seine data were available.

Determination of entry into the fishery was made using length-at-age estimates (Hill and Loesch, 1994a) and Virginia Marine Resources Commission (VMRC) minimum legal length regulations² (Table 2). Usually changes in harvest regulations took effect in the middle of the year. For years during which a change occurred, the minimum length that was legal for any part of that year was used to determine entry into the fishery. Although female striped bass grow faster than males (Hill and Loesch, 1994a), the difference was not great enough to cause females of any year class to enter the fishery earlier. Therefore, pooled estimates for length at age were used in the model.

Only the nonmigratory striped bass stock was considered in this model. The migratory stock is not present in large numbers in the rivers where juvenile crabs are plentiful during the months that small crabs are most abundant. This is also the period for which the VIMS blue crab juvenile index is calculated, September through

1 Louis J. Rugolo kindly provided us with estimates for several parameters used in this model. His research in the Maryland portion of Chesapeake Bay was the best source of information on fishing, poaching and, hook and release mortalities, as well as recent (post 1985)age at migration rates.

2 VMRC revises and publishes Regulation Number450-01-0029 "Pertaining to the taking of Striped Bass" each year. The regulations are available from VMRC.

TABLE 1. The data used in the regressions.

Yr	1	2	3	4	5	6
80				2.2		
81				0.9		
82				1.6		
83				3.1		
84				3.5		
85	4.9	4.15	22.69	8.25	49.24	1.6
86	4.3	1.89	7.06	0.74	4.33	5.0
87	6.8	2.94	11.82	0.41	4.02	10.2
88	12.9	14.8	3.22	13.46	9.88	12.28
89	11.2	14.5	10.76	12.17	7.21	9.80
90	13.4	17.8	15.62	42.97	31.46	65.82
91	13.5	17.6	8.66	5.48	11.28	7.66
92	10.3	15.0	6.72	4.14	3.60	5.33
93	8.2	13.9	5.98	9.10	8.04	10.07
						12.4
						**
						24.57

1. Predicted, relative, resident striped bass
 2. Predicted, relative striped bass
 3. Fall blue crab index
 4. Spring blue crab index
 5. Fall, Rappahannock River blue crab index
 6. Spring, Rappahannock River blue crab index
 7. Striped bass juvenile index
 8. Fall Rappahannock River pound net striped bass CPUE
 9. Spring Rappahannock River pound net striped bass CPUE
- * No data collected.
** Data not available at time of analysis.

TABLE 2. Virginia commercial harvest regulation for striped bass minimumlengths.

Year	70-85	1986	87-90	91-93
Total length (inches)	14	18	24	18

November. Data on commercial catch-per-unit-effort (CPUE) of striped bass are reported by Hill and Loesch (1994a) by year class, season (spring and fall), and by river mile on the Rappahannock River for the period 1986-1993. From the fall data we recalculated CPUE by fish age for the entire river (Table 3), and found that fish older than five years were not present in abundance. The fraction of each year class not joining the migratory stock was estimated from age at migration rates (Rugolo, pers. comm.), except that age 6+ fish were considered to have entirely recruited to the migratory stock (Table 4). Although it is commonly thought that female striped bass begin migrating at an earlier age (Setzler et al., 1980), no difference arises in predicted population by sex at the ages under consideration here. Therefore, we pooled the estimates for percent migration.

TABLE 3. Fall Rappahannock River striped bass CPUE by age and year.

Yr	Age							
	1	2	3	4	5	6	7	8
86	29.33	15.40	5.33	0.93	0	0	0	0.07
87	1.36	25.25	7.14	3.82	0.71	0.04	0.07	0
88	3.46	30.64	16.43	5.21	1.11	0.11	0.07	0
89	1.52	29.52	32.71	9.14	1.76	0.19	0	0
90				No Data				
91	0.04	10.43	26.04	11.30	4.22	0.74	0.04	0
92	6.50	35.25	54.25	39.25	4.25	0.25	0	0

TABLE 4. Chesapeake Bay striped bass residency rates.

Age	Rate
0	1.000
1	1.000
2	0.900
3	0.575
4	0.575
5	0.575
6+	0.000

Thus, the resident bass model (RB) has the form

$$R B_t = \sum_{j=t-1}^{t-5} \bar{x}_{gj} \left[e^{-\sum_{i=j+1}^t Z_i} \right] R_{t-j}, \quad [\text{Eqn. 3}]$$

where t is the year for which the resident bass are being predicted, and R is the residency rate for fish of a particular age [e.g., suppose $t = 1988$ and $j = t - 2 = 1986$, then $t - j = 2$, so we use the residency rate for two year olds. At the same time, we use

$$\left(e^{-(Z_{1987} + Z_{1988})} \right), \quad [\text{Eqn. 4}]$$

for survival.]

The estimates for surviving, resident, striped bass of ages 1-5 were summed for each of the years 1985-1993 (Table 5). These were regressed against the VIMS juvenile blue crab index for those years (Table 1). This index is calculated using data collected with an otter trawl from September through November. This is also a weighted, geometric mean, and is calculated as above except that the weighting factor and summation across the six strata are moved inside the back-transformation:

TABLE 5. Predicted relative abundance of striped bass by age and year.

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993
5	.04	0.05	0.12	0.54	0.67	0.24	0.61	1.21	0.41
4	.07	0.15	0.67	0.83	0.38	0.95	1.89	0.63	1.64
3	.33	0.84	1.04	0.48	1.48	2.95	0.99	2.56	1.73
2	1.63	2.02	0.92	2.88	5.88	1.96	5.09	3.45	1.70
1	2.80	1.28	4.00	8.16	2.80	7.25	4.91	2.42	3.60
Sum	4.87	4.34	6.75	12.89	11.21	13.35	13.49	10.27	9.08

TABLE 6. Spring Rappahannock River striped bass CPUE by age and year.

Yr	Age												
	1	2	3	4	5	6	7	8	9	10	11	12	13
87	0.02	0.76	2.53	4.55	2.10	0.31	0.16	0.02	0.10	0.02	0	0	0
88	1.97	2.75	2.36	1.86	0.61	0.03	0.06	0	0	0	0	0	0
89	0	0.44	4.81	1.93	1.09	1.21	0.30	0.16	0.02	0	0	0	0
90	0	2.73	2.45	3.09	3.00	2.09	1.09	0.55	0.45	0.09	0	0	0
91	0.40	0.45	2.60	5.05	2.45	1.10	0.45	0.15	0.10	0.30	0.05	0	0
92	0.12	0.29	0.48	1.40	2.36	0.88	0.31	0.24	0.10	0.17	0.07	0	0
93	0.13	0.65	1.17	4.04	10.78	4.13	0.74	0.47	0.65	0.52	0.35	0.30	0.17

$$\bar{x}_g = \log^{-1} \left[\sum_{k=1}^6 \left[(wt_k) \left[\frac{\sum_{i=1}^n \log(x_{ik} + 1)}{n_k} \right] \right] \right] - 1 , \quad [\text{Eq.5}]$$

where the weights (wt_k) are calculated from the surface areas of the strata, two each for the three Virginia rivers, James, York and Rappahannock (Figure 2). Here k identifies the stratum and n_k is the number of otter trawl tows in the k^{th} stratum (Bonzek, pers. comm.).

Because juvenile blue crabs are active during at least the warmer periods of the winter, the model was adjusted to predict migratory plus nonmigratory relative bass population. This was done by simply removing the residency component R , and summing predicted relative bass of ages 1 - 8 (Table 1). Although the Rappahannock River pound net CPUE data (Hill and Loesch, 1994a) indicate that a few fish older than eight years were present in the winter months, the number is very small.

The juvenile blue crab index was recalculated for the months May and June (1985-1993), taking into account growth since the previous fall. Where crabs ≤ 65 mm were considered juveniles in the fall, the new limits were ≤ 80 mm (May) and ≤ 100 mm (June).

The spring juvenile blue crab index was regressed against the predictions of the striped bass model and the resident striped bass model.

TABLE 7. Summary of results for blue crab v. striped bass linear regression analyses.

Regression	R ²	p
Fall blue crab juvenile index v. predicted resident striped bass index	0.451	0.048
Spring blue crab juvenile index v. resident + nonresident striped bass index	0.283	0.278
Rapp. R. fall blue crab juvenile index v. fall striped bass pound net index	0.001	0.951
Rapp. R. spring blue crab juvenile index v. spring striped bass pound net index	0.059	0.601

Indices of adult striped bass abundance for the Rappahannock River, Virginia were constructed from pound net data (Hill and Loesch, 1994a,b). The catch-per-unit-effort (CPUE) was calculated by year for each of the two collection periods, fall and spring (Table 1). Since few fish older than five years are collected in the fall sampling, this collection is thought to represent only year-round resident fish. The spring collection includes adults up to 13 years old, and is considered a sample of the combined resident and migratory stocks (Table 6).

Indices of juvenile blue crab abundance were constructed for the fall and spring periods defined above, using only data from the Rappahannock River (Table 1). Fall and spring indices of juvenile blue crab abundance were then regressed against respective Rappahannock River striped bass indices.

Data on which all indices are based are fishery-independent, and are independent of each other. The juvenile striped bass data are gathered with a beach seine during the summer (July-Sept.) in the nursery grounds of the three major rivers in the Virginia portion of the Chesapeake Bay. The adult striped bass are collected with pound nets on the Rappahannock River in two collections in the fall and spring, and the juvenile blue crab data are collected by otter trawl throughout the Virginia rivers, during the months September through November for the fall crab index, the months during which small crabs are most abundant, and during the months May and June for the spring blue crab index.

RESULTS and DISCUSSION

We found a significant positive linear relationship between predicted resident bass and juvenile blue crabs (Figure 1 and Table 7). This relationship reflects a rise and subsequent fall in blue crab numbers (Figure 2). The rise and fall in predicted resident striped bass numbers (Figure 2) can be attributed largely to strong year classes in 1987 and 1989 in the following manner. The 1987 year class entered the residence index in 1988, and inflated it. The 1988 year class was small, entered the model in 1989, and at the same time 10% of the 1987 year class emigrated with the migratory stock, causing a decline in the residence index. Then, in 1990, the strong 1989 year class entered the resident stock, elevating the index, and the 1990 year class was strong enough that a decline was not seen until 1992. Relatively weak year classes in 1991 and 1992, along with most of the 1987 and many of the 1989 fish entering the migratory stock, largely explain the decline. Considering the great differences in the life histories of these species, and the different management practices, the apparent association between blue crabs and striped bass may be coincidental.

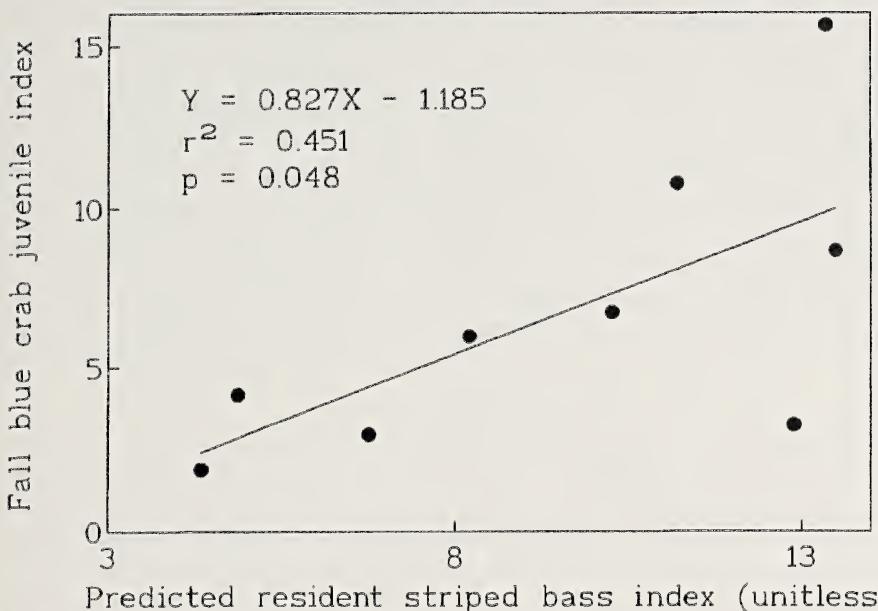


FIGURE 1. Scatter plot and regression analysis of the prediction of the resident striped bass model versus the fall blue crab juvenile index.

Juvenile blue crabs are active in submerged aquatic vegetation beds at least part of the winter (Orth and van Montfrans 1987). To test for predation by striped bass during this period, when the migratory stock is present in the Chesapeake Bay, the migration component was removed from the striped bass model, and predicted adult striped bass were compared to the spring crab index (Table 7). That no relationship was detected may be related to striped bass staying in deep water during the winter, and not in places where crabs are active. Also, after April spawning, fish recruited to the migratory portion of the stock migrate rapidly from the Bay and are gone by mid-May.

The Rappahannock River fall pound net catch-per-unit-effort (CPUE) can be considered a measure of resident striped bass abundance. Migratory fish (ages 6+) constitute a small portion of the fish captured during this period. However, these data do not correlate with the fall blue crab trawl survey index calculated only with Rappahannock River data (Table 7).

The Rappahannock River spring pound net CPUE, a measure of migratory and nonmigratory striped bass abundance, was compared to the Rappahannock River spring blue crab index (Table 7). No relationship was evident in these expressions.

Although striped bass eat juvenile blue crabs (Hollis 1952), examination of the potential relationships between striped bass and juvenile blue crab abundance showed no evidence that increases in bass abundance resulted in declining blue crab abundance. Striped bass predation on blue crabs is dependent on encounters with crabs of suitable size and abundance during times of the year when bass are feeding regularly. For example, striped bass in Long Island Sound, NY showed an increase in fish consumption and a decrease in invertebrate consumption between spring and autumn due to a

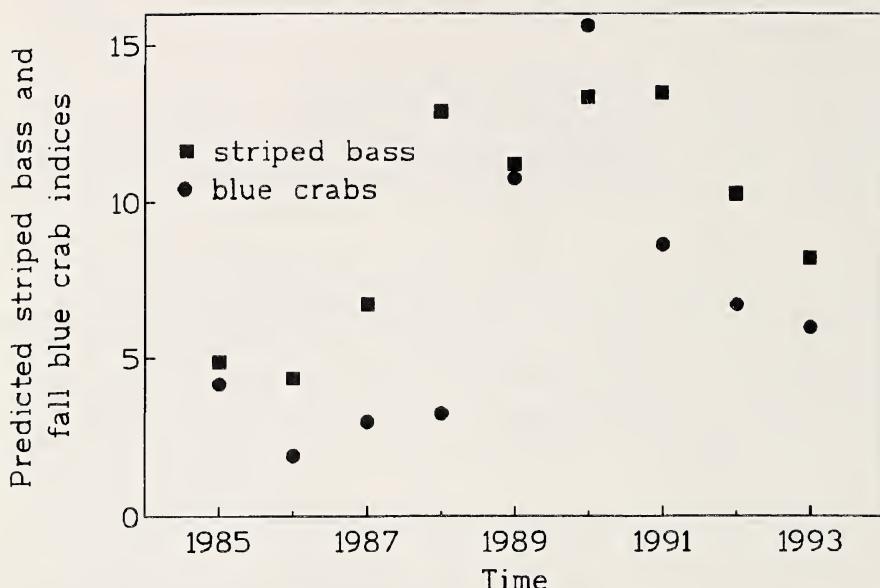


FIGURE 2. Prediction of the resident striped bass model and the blue crab juvenile index over time.

shift in prey availability (Schaefer 1970). Similarly, striped bass in Albemarle Sound, NC consumed more invertebrates in winter and spring than at other times (Manooch 1973).

As migratory fish are present in Chesapeake Bay in winter and spring, we compared juvenile blue crab abundances to resident and non-resident striped bass numbers, using two estimates of bass abundance. Predation by non-resident striped bass should end in May because these fish leave Chesapeake Bay to migrate north. We chose to estimate juvenile blue crab abundance with trawl data from the months May and June because no juvenile recruitment takes place this early and juvenile blue crab abundance should fully reflect predation. Using two different estimates for striped bass abundance compared to appropriate juvenile blue crab abundance estimates, no significant relationships were found (Table 7). The migratory nature of striped bass may influence predation on blue crabs. In Chesapeake Bay and Hudson River, striped bass less than two years old (< 300 mm) do not migrate extensively from their natal rivers (Vladykov and Wallace 1938, Raney 1952, Massman and Pacheco 1961, Mansueti 1961, Setzler et al. 1980), although more two year old striped bass leave the Bay when their cohort is strong (Austin and Hickey 1978). Approximately 10% of two year old striped bass usually leave the Bay (Raney 1952). Extensive migration out of the Chesapeake Bay and northward along the Atlantic Coast normally begins at 3+ years of age (Mansueti and Hollis 1963). Maryland female bass typically make their first oceanic migration at an early age (3+), whereas males may not leave the Bay for the first time until they are 5 or 6 years old (Setzler et al. 1980). During the winter, adult striped bass remain relatively inactive, reduce food consumption, and congregate in deeper (10-50 m)

portions of river mouths and the Bay (Raney 1952). As waters warm in early spring, mature fish move upstream to freshwater spawning grounds. After spawning in April and May, migratory bass rapidly leave the Bay and move northward along the Atlantic Coast (Raney 1952). This migratory stock moves southward in the autumn, returning to the Bay in November and December to overwinter with younger bass that remained during the summer. Migratory striped bass are not present in the Bay for most of the time that crabs are active. Younger, non-migratory striped bass are most likely to have a detectable influence on juvenile blue crab abundance because they are present during the times when crabs are most abundant. Our comparisons revealed a significant, positive regression between predicted, resident, striped bass and the fall juvenile blue crab index, not an inverse relationship. While we have no explanation for this apparent coherence between these populations, it certainly does not suggest that striped bass predation controls juvenile blue crab abundance.

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T.C. Mosca III developed the mathematical models, P.J. Rudershausen conducted the literature review, and together Mosca and Rudershausen analysed the data. R.M. Lipcius provided insight into the potential predator-prey relationship, and life history of the blue crab.

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Abstracts of Papers Presented at the Symposium on Status of the Chesapeake Bay

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PREFACE

The Symposium, *Status of the Chesapeake Bay*, was hosted by the Science Museum of Virginia during its annual Bay Days Festival on March 9, 1996. Presented here are abstracts of papers that included discussions in community interactions, biodiversity, population ecology, and wetlands in the ecosystem, and toxics reductions and mitigation strategies and technologies currently employed and planned for clean-up of the Chesapeake Bay. The symposium was supported in part by Albright & Wilson Americas, Science Museum of Virginia Foundation, Virginia Academy of Science, and Westvaco.

CURRENT STATUS AND TRENDS OF THE CHESAPEAKE BAY. Kent Mountford, US Environmental Protection Agency Chesapeake Bay Program Office, Annapolis, MD 21403.

A geological perspective stretching back 35 million years sets the scene for today's problems which began about 100 years ago after European settlement. Changes in agricultural practices, the flooding of nutrients into the estuary and the myriad of impacts of human growth and industry have greatly stressed the Bay's natural populations, and focused people on the need for restorative actions. The Chesapeake Bay Program brought together state, municipal, and citizen actions with a catalyst of Congressional dollars funneled through the USEPA to reduce pollution and change the way we live. Over the last 12 years the Bay has begun to show some positive responses, like increasing Bay grasses, though many environmental problems remain. Some fishery resources are in deep trouble but management changes have made a healthy striped bass harvest possible and shad are on the increase. Setting goals is one way to keep our feet to the fire, but be sure what we measure to track progress is connected to the cleanup actions we take.

STATUS AND TRENDS OF WATER QUALITY IN RIVERS ENTERING CHESAPEAKE BAY AT THE FALL LINE. Clifton F. Bell and Linda D. Zynjuk, U. S. Geological Survey, Water Resources Division, Richmond, VA 23230

The U. S. Geological Survey, in cooperation with the Maryland Department of Natural Resources, the Metropolitan Washington Council of Governments, and the Virginia Department of Environmental Quality, is monitoring the amount of nutrients and suspended sediment entering the tidal portion of Chesapeake Bay watershed from the nine largest tributaries. Results indicate that between 1985 and 1994, approximately 97% of freshwater nitrogen load to the Bay came from the Susquehanna, Potomac, and

James Rivers; the Susquehanna River alone contributed almost 70% of the total nitrogen load. Similarly, about 90% of the freshwater phosphorus load came from the Susquehanna, Potomac, and James Rivers. The James River, which contributed only about 15% of the freshwater flow to the Bay during that same period, contributed over 25% of the mean annual phosphorus load. Trend analysis indicates that flow-corrected total nitrogen concentration decreased almost 14% in the Susquehanna and Potomac Rivers between 1985 and 1994, with no significant trends detected in the Potomac and James Rivers. Flow-corrected total phosphorus concentration decreased 47% in the Susquehanna River, 42% in the Potomac River, and 22% in the James River. The decrease in nutrient concentrations can be attributed to a number of factors, including upgrades of waste-water treatment plants, a ban on phosphate-containing detergents, and agricultural best-management practices. Despite the decrease in total nitrogen concentration, dissolved nitrate concentration increased 18% in the Susquehanna River between 1985 and 1994. In order to better understand the importance of various point and nonpoint sources on nutrient loads and trends of rivers entering the Bay, the U. S. Geological Survey will be conducting a statistical analysis factors controlling nutrient and sediment fluxes in the non-tidal portion of the Bay watershed. This analysis may help assess and predict the effect of watershed management strategies in reducing nutrient and sediment loading to Chesapeake Bay.

CHESAPEAKE BAY PHYTOPLANKTON: PRESENT COMPOSITION, ABUNDANCE, AND DISTRIBUTION PATTERNS. Harold G. Marshall and Raymond W. Alden, Department of Biological Sciences, Old Dominion University, Norfolk, VA 23529.

Phytoplankton represent one of the most significant and abundant plant communities in Chesapeake Bay, providing the major source of food and oxygen to fauna within various food webs in the estuary. The phytoplankton contain over 700 species that annually have their greatest abundance and productivity associated with seasonal blooms during late winter-early spring, summer, and fall. Spatial differences in composition among phytoplankton exist seasonally above and below the pycnocline, and in different regions of the Bay. Highest cell concentrations are within river plumes along the western Bay, where nutrient levels are greatest. Productivity peaks are associated with the seasonal abundance maxima of both phytoplankton and specifically the autotrophic picoplankton component, which is most abundant during summer. Relationships between these factors and the health status of Chesapeake Bay are discussed in relation to long term trend analysis results based on the composition and abundance of the phytoplankton. Supported by the Virginia Department of Environmental Quality and US Environmental Protection Agency.

TECHNIQUES FOR MEASURING AND ASSESSING TRENDS IN DIS-SOLVED OXYGEN. Elgin S. Perry, Elgin S. Perry Statistical Consulting, Huntingtown, MD.

Low dissolved oxygen (DO) is a widely perceived indicator of an unhealthy Bay. DO is vitally important in itself because it can have a direct and drastic effect on living

resources that are recreationally and commercially valuable. It also plays the role of an "integrator" parameter for many other processes that affect water quality. It is important to quantify trends in this parameter, and responses that it may have to management actions designed to improve the water quality of the Bay. Historical investigations have shown that the multi-dimensional nature of DO and its responsiveness to natural forcing functions make it difficult to quantify it in a measure that separates trends from natural variability. This paper presents techniques for quantifying DO response, and methods for statistically segregating natural and anthropogenic influences on DO response to facilitate trend assessment.

VIRGINIA'S WILDLIFE INFORMATION ON-LINE SYSTEM: OPENED DOORS FOR INCREASED DATA SHARING. Tom Wilcox, Aquatic Analyst, Virginia Department of Game and Inland Fisheries, Richmond, VA 23230.

In 1994, the Virginia Department of Game and Inland Fisheries (VDGIF) implemented a microcomputer-based on-line system allowing access to the agency's numerous biological information systems. This centralized approach offers VDGIF an opportunity to make information related to fish and wildlife resources and habitats available to users outside of the Department. This on-line service not only makes fish, wildlife, and related information available to other users, but includes numerous query and report features to facilitate data retrieval and summary within and across independent applications and components. The system currently has a number of features : (1) comprehensive species information (e.g. food habits, life history, habitat associations, status, and taxonomy); (2) maps showing species distributions; (3) geographic querying; (4) "e-mail" functions to allow users and the system administrator to exchange messages regarding systems, data, reports, or other features; (5) local printing capabilities to provide users with hardcopy results; and (6) system documentation and on-line help. This session will concentrate on the use of the On-Line Service in determining the presence/absence of species within a specific geographical area. This type of query is frequently used in addressing land management issues, comprehensive planning, and research. Future additions to the On-line system include an anadromous fish impediment database, butterfly and freshwater mussel databases, scanned photographs of species and habitats, and enhanced interactive mapping.

TOXIN PRODUCING ALGAE WITHIN CHESAPEAKE BAY. Harold G. Marshall, Department of Biological Sciences, Old Dominion University, Norfolk, VA 23529.

There is an apparent global increase in the occurrence of bloom and toxin producing algae (phytoplankton) in coastal and estuarine habitats. In Chesapeake Bay and its tributaries, non-toxin producing algal blooms are common from spring through fall, with indications of greater frequency of occurrence in southern Bay estuaries. Toxin producing algae, with bloom potential, also have been identified in the Bay, and these species have been monitored the past decade within Chesapeake Bay Phytoplankton Monitoring Program and from other collections examined by the author. These data sources have provided spatial and temporal information on the abundance and distri-

bution of 16 algal species that are known to produce toxins that have been linked to shellfish poisoning (e.g. ASP, DSP) and/or fish kills at other locations. Although there have been no major toxic events produced in Chesapeake Bay to date, the Bay waters contain species with this capability. Supported in part by the Virginia Department of Environmental Quality and US Environmental Protection Agency.

BACK TO THE FUTURE: THE HISTORICAL ECOLOGY OF THE JAMES RIVER, VIRGINIA. Greg C. Garman,¹ Mark A. King,¹ and Stephen A. Macko.² Center for Environmental Studies and Department of Biology, Virginia Commonwealth University, Richmond, VA 23284¹ and Department of Environmental Sciences, University of Virginia, Charlottesville, VA 22903.²

Although pollution from industrial and municipal point-sources has been shown to affect the composition and structure of riverine fish and macroinvertebrate assemblages, two other human activities -- the construction of dams and the widespread introduction of nonindigenous species -- may have had an even greater impact on important ecological interactions in Atlantic slope rivers. Based on quantitative sampling throughout the James river mainstem during the period 1987-1990, numerical dominance of 15 non-native fishes, including several large, long-lived predator taxa, ranged from 37 to 89 percent, and was greatest at sites affected by mainstem impoundment. Twelve mainstem dams on the James river have also barred anadromous clupeid fishes, including American shad and blueback herring, from the nontidal James river and its tributaries for at least a century. Several lines of evidence, including stable isotope ratio analysis, suggest that prior to the creation of blockages, these migrations represented critical ecological and energetic linkages between inland freshwaters and coastal oceanic ecosystems. Current management efforts to re-establish anadromous fishes within their historical range may be compromised by changes in the historical fish assemblage, and particularly the ecological dominance of nonindigenous fishes, since anadromous species last migrated freely throughout the James river basin.

PRECISION AND ACCURACY OF THE AGE ESTIMATION PROCESS FOR TIDAL FRESHWATER FISHES. Mark A. King,¹ Greg C. Garman,¹ Dean L. Fowler,² and David Dowling² Department of Biology, Virginia Commonwealth University,¹ Richmond, VA 23284 and Virginia Department of Game and Inland Fisheries,² Williamsburg, VA 23188.

Inaccurate aging of fishes can result in underestimates of longevity and development of erroneous growth models. Validation with known-age individual fish, though not typically employed, remains the only irrefutable test for accuracy of fish age estimates from annuli of calcified body structures. In this study, annuli counts of scales were graphically and statistically compared with annuli counts from thin transverse sections of corresponding sagittal otoliths; striped bass annuli were validated with known-age individuals. Samples from exploited tidal fish populations, including migratory and anadromous species, were included in the analyses. Results for largemouth bass ($n=31$), white perch ($n=40$), yellow perch ($n=58$) and striped bass ($n=232$; $n=105$ of known age) indicate similar trends. Scales were accurate or were overesti-

mators for lower otolith annuli counts, but when otolith annuli counts were higher, scales were strongly biased underestimators. Otolith ages were accurate for 94% of known-age striped bass. Individuals with greater than expected otolith annuli counts for several species may confirm our view that use of scales in the past has resulted in overestimates of production of large individuals and underestimates of longevity, even for relatively well studied species such as largemouth bass.

A MULTI CRITERIA WETLANDS EVALUATION METHODOLOGY.

Sharon Demonsabert, Eileen Bienvenu, and Deborah Branson, USN. Department of Biological Sciences, George Mason University and Office of the Assistant Secretary of the Navy (Installations and Environment).

By its very nature of activity, the Department of the Navy is generally located near water front. Some Naval bases were not constructed in an environmentally sound manner. Now reflecting a strong commitment to ecologically balanced practices the philosophy has changed. The Navy is committed to a number of ongoing projects in the Chesapeake Bay watershed including planting riverine buffers, shoreline stabilization, wetlands restoration and construction, and control of contaminated runoff. Several Virginia and Maryland universities are involved in many of these projects which involve the protection of both freshwater and saltwater regimes. A multi criteria evaluation methodology is under development to be used for the comparison of wetlands projects. Collected data from a number of Naval bases on the Chesapeake Bay will be used to develop wetland evaluation criteria. Sample data are presented from an ongoing project at Quantico Marine Corps Base on the Chesapeake Bay. It is planned to collect this information for representative samples of 404 permit applications nationwide. The collected data will be used to quantify the ecosystem benefits and disbenefits resulting from current wetlands legislation. Some of the factors to be addressed in the multi criteria approach include economic considerations such as minimizing cost through innovative manpower and equipment sharing with other agencies and the civilian sector, environmental considerations such as water quality enhancement and analysis of the value of existing biodiversity, the functions defined by the hydrogeomorphic classification of wetlands, and compliance with the goals of the Chesapeake Bay Initiative.

CHESAPEAKE BAY TOXICS REDUCTIONS UNDER VIRGINIA'S FEDERAL FACILITIES RESTORATION PROGRAM. David V. Grimes, Office of Federal Facilities Remediation, Virginia Department of Environmental Quality, Richmond, VA 23219.

Toxics reduction strategies for the Chesapeake Bay involve programs, agreements, and statutes governing toxics at Federal Facilities. Prominent examples include the Department of Defense (DOD) Cooperative Agreement on the Chesapeake Bay, the Agreement of Federal Agencies on Ecosystem Management in the Chesapeake Bay, DOD's Installation Restoration Program (IRP), and the Base Realignment and Closure (BRAC) Act. The IRP and BRAC programs drive many of DOD's toxics related activities due to their embodiment of the Comprehensive Environmental Response,

Compensation and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA). These acts provide for coordination of toxics issues between state and federal agencies. Toxics reductions accomplished through this coordination include removal of contaminated sediments, stabilization of point sources, and removal of petroleum product tanks. These reductions highlight how risks to human health and the environment can be reduced through cooperative agreements which fund and empower parties. Expansion of the federal-state partnering model to include local governments and the private sector offers potential for accelerating restoration of the Chesapeake Bay.

GEOGRAPHIC INFORMATION SYSTEM DATA BASE FOR THE ELIZABETH RIVER WATERSHED, VIRGINIA. George E. Harlow Jr., Todd W. Augenstein, Theodore, D. Samsel III, and Willet D. Wilson. U.S. Geological Survey, Water Resources Division, Richmond, VA 23230.

A geographic information system (GIS) data base was created by the U.S. Geological Survey (USGS) for the Elizabeth River watershed, which drains to Chesapeake Bay. The effort, which began in May 1995, was done by the USGS in cooperation with the Chesapeake Bay Office of the Department of Environmental Quality. The Elizabeth River watershed lies within the Coastal Plain physiographic Province. The watershed covers part, or all, of nine 1:24,000-scale topographic maps (with Norfolk South quadrangle at the center). The watershed drains about 250 square miles of heavily industrialized land around Norfolk, including Suffolk, Chesapeake, Portsmouth, and Virginia Beach. The GIS data base includes spatial information on hydrography, transportation, hypsography, well sites, permitted return-flow sites, drainage basins, hydrogeology, and potential hazardous-waste sites listed in an U.S. Environmental Protection Agency historic photographic inventory (years 1937-86). The GIS data base was created for use in environmental studies requiring spatial analysis, display, and management of hydrologic and environmental information; for example, potential hazardous-waste sites can be spatially displayed with respect to specific drainage basins to identify potential contributions of hazardous materials to different river segments.

THE DEPARTMENT OF DEFENSE AND THE CHESAPEAKE BAY PROGRAM. Steven G. Olson. Commander Naval Base Norfolk, Norfolk, VA 23511-2797.

The Department of Defense owns 66 installations in the Chesapeake Bay watershed, and has pledged to support Bay cleanup efforts in a 1984 Memorandum of Understanding with the Environmental Protection Agency, and in three subsequent agreements in 1990, 1993, and 1994. The Chesapeake Bay Program under the Environmental Protection Agency encourages partnerships between federal, state, and local agencies to carry out cleanup goals and commitments made under these agreements. Commander Naval Base Norfolk was assigned Navy Chesapeake Bay Program coordination responsibilities in 1988, and Department of Defense Executive Agent role in June 1994. The major responsibility under this executive agent role is to coordinate multi-service efforts to achieve commitments made in various Chesapeake Bay Pro-

gram agreements. Recent Department of Defense (DOD) initiatives of note are as follows: Improve public access to the Bay at DOD installations; remove impediments from waterways which could impact migration of fishes; restoration of aquatic, riparian and upland fish and wildlife habitat at DOD installations; commitment of 40 % reduction of nutrient releases from DOD installations by the year 2000 through wastewater treatment plant upgrades and nutrient reduction plans; and commitment of 75 % reduction in toxic releases from DOD installations by the year 2000 through incorporation of techniques such as Integrated Pest Management.

THE CURRENT STATUS OF LIVING RESOURCES IS INDICATIVE OF THE HEALTH OF THE CHESAPEAKE BAY. Jean Watts, Chesapeake Bay Foundation, Richmond, VA 23219.

Chesapeake Bay is the nation's largest estuary, a place where the freshwater of 48 major rivers and 100 smaller tributaries mix with seawater to produce a productive and diverse ecosystem. One way to evaluate the status of this complex ecosystem is to examine the current status and recent trends of living components of the Bay that both contribute to and depend on a healthy system. The four indicators (wetlands, submerged aquatic vegetation, oysters, and fishes) examined in this paper are essential natural resource constituents of the Chesapeake Bay. Wetlands make up less than four percent of the watershed but are essential to the biological, physical, and chemical integrity of the Bay. Since Colonial times, Virginia's wetland acres have decreased over 40 %, Pennsylvania's by over 50 %, and Maryland's by over 70 %. In just the last eight years, the collective loss of wetland acres in the watershed equaled the size of Washington, DC. Submerged aquatic vegetation (SAV) provides numerous benefits to the Bay and is sensitive to water quality. SAV has declined in all reaches resulting in less than 12 % of historic levels. The overall status of the Bay's fisheries is poor. A few species seem to be stable and some are showing improvement, but the majority of species are either declining or are depleted. The oyster population in the Bay has declined to less than one percent of its historic levels. The numbers of oysters are so low that the species is likely to become commercially, if not biologically, extinct in the Bay.



LAWRENCE I. MILLER 1914-1996

Lawrence I. Miller, long-time member of the Virginia Academy of Science, died March 8, 1996 from complications following an operation. Miller was born in Jackson Center, Ohio, May 12, 1914. He received a B.S. degree from Oberlin College in 1936, an M. S. degree from Virginia Polytechnic Institute in 1938, and a Ph.D. degree from the University of Minnesota in 1953. He worked as a peanut plant pathologist at Holland (now Suffolk), Virginia from 1938 to 1942, and 1949 to 1969. He served during World War II as an artillery officer in the U. S. Marine Corps, 1942-1945. From 1945 to 1949, he was a graduate student in plant pathology at the University of Minnesota. During his tenure at Holland, peanut yields were more than doubled as a result of his research. In 1969, he was transferred to Blacksburg where he conducted

research on the taxonomy of cyst nematodes (*Globodera* and *Heterodera*) affecting crops in Virginia and on hybridization among various species of native and exotic cyst nematodes. He retired and was named Professor Emeritus in 1980, but he continued his research up to his death.

Dr. Miller received the J. Shelton Horsley Award in 1960, was chairman of the Agricultural Section in 1962, and remained a member of the Academy at least through 1991. He presented papers almost annually at Academy meetings. In the American Phytopathological Society, he was President of the Potomac Division in 1968, and Councilor, 1969-1971. The Potomac Division granted him a Distinguished Service Award in 1987. He was President of the Society of Nematologists, 1976-1977, and was named Honorary Member in 1981. He received the Golden Peanut Research Award from the National Peanut Council in 1966. In 1980, he was named the first Honorary President of the newly-formed Society of Mexican Nematologists and in 1994, he was elected an Honorary Member of the Organization of Nematologists of Tropical America. Lawrence Miller served his country, agriculture, professional societies, and science in an exemplary fashion.

Dr. Miller is survived by his wife, Mary McBryde Miller, a son Lawrence I. Miller, Jr., both of Blacksburg, Virginia, and a daughter, Polly Ashelman, Colonia, New Jersey.

(The family of Lawrence Miller has agreed to join with the Department in establishing a memorial scholarship fund in his name. For details, interested persons should contact Dr. Laurence D. Moore, Head, Department of Plant Pathology, Physiology and Weed Science, VPI and SU, Blacksburg, VA 24061-0331, or call 540-231-6361. E-mail address is larrydm@vt.edu; FAX 540-231-7477.)

JEFFRESS RESEARCH GRANT AWARDS

The Allocations Committee of the Thomas F. and Kate Miller Jeffress Memorial Trust has announced the award of Jeffress Research Grants to the institutions listed below to support the research of the investigator whose name is given. The Jeffress Trust, established in 1981 under the will of Robert M. Jeffress, a business executive and philanthropist of Richmond, supports research in chemical, medical and other natural sciences through grants to non-profit research and educational institutions in the Commonwealth of Virginia. The Jeffress Research Grants being announced here have been awarded in 1995.

The Jeffress Memorial Trust is administered by NationsBank of Virginia, N. A. Additional information about the program of the Trust may be obtained by writing to: Advisor, Thomas F. and Kate Miller Jeffress Memorial Trust, NationsBank, Private Client Group, P. O. Box 26688, Richmond, VA 23261-6688.

Samuel A. Abrash, University of Richmond. Photochemistry of Complexes of Hydrogen Sulfide with Acetylene and Ethylene and Hydrogen Halides with Propyne and Propylene in Argon Matrices. \$15,918 (one year).

David S. Armstrong, College of William and Mary. Nuclear Weak Interactions and Muon Molecular Physics. \$17,960 (one year).

Dieter K. Bartschat, Eastern Virginia Medical School. Developmental Aspects of Pb+2 Toxicity. \$19,500 (one year).

Deborah C. Bebout, College of William and Mary. Mechanistic Comparison of Evolutionarily Divergent Peptidyl α -hydroxylating Monooxygenases. \$10,000 (one year renewal).

David R. Bevan, Virginia Polytechnic Institute and State University. Structural Analysis of NtcA. \$5,000 (one year).

Karen J. Brewer and Brenda W. Shirley, Virginia Polytechnic Institute and State University. New Multimetallic Platinum Complexes as Anti-Cancer Agents. \$20,000 (one year).

William C. Broaddus, George T. Gilles, and John E. Stewart, Medical College of Virginia Foundation-Virginia Commonwealth University. Improved Medical Imaging for Neurological Procedures. \$10,000 (one year renewal).

Michael A. Calter, Virginia Polytechnic Institute and State University. Bifunctional Catalysts for Enolate Generation. \$20,000 (one year).

Fu-Lin E. Chu , College of William and Mary-Virginia Institute of Marine Science. Role of Lipids and Fatty Acids in Development and Proliferation of the Oyster Protozoan Parasite, *Perkinsus marinus*. \$17,975 (one year).

Gary F. Clark, Eastern Virginia Medical School. Isolation of Selectin-Ligand Binding Protein from Human Sperm. \$21,341 (one year)

Claire Cronmiller, University of Virginia. Molecular and Genetic Characterization of *I(3)1344*, a Gene Required for Ovarian Follicle Formation in *Drosophila*. \$9,775 (one year renewal).

Alan C. Dalkin, University of Virginia. Regulation of Gonadal Activin Receptor Gene Expression. \$13,438. (one year renewal).

Robin Lee Davies, Sweet Briar College. Assembly of a Cosmid-Based Physical Map of Chromosome 12q13. \$18,568 (one year).

Paul A. Deck, Virginia Polytechnic Institute and State University. Chiral Constrained - Geometry Complexes. \$20,000 (one year).

M. Samy El-Shall, Virginia Commonwealth University. Gas Phase Polymerization Catalyzed by Metal Cations. \$10,000 (one year renewal).

Felicia A. Etzkorn, University of Virginia. Inhibition of Cyclophilin A and Stabilization of Rnase T1 by a Mimic of cis-Proline. \$19,700 (one year).

Reyna Favis, Virginia Polytechnic Institute and State University. Investigating Differentiation in *Dictyostelium discoideum* through the Analysis of Glycogen Phosphorylase 2 Gene Regulation. \$20,000 (one year).

John B. Fenn, Virginia Commonwealth University. Quantitive Analysis with Electrospray Mass Spectrometry. \$19,149 (one year).

Samuel A. Green, University of Virginia. Rapid Lysosomal Targeting of Amyloid Precursor Protein. \$11,000 (one year renewal).

Charles M. Grisham, University of Virginia. Structure and Mechanism of Protein Kinase C Isozymes. \$19,000 (one year).

Fred M. Hawkrige, Virginia Commonwealth University. Experimental and Theoretical Examination of the Models for Direct Electron Transfer of Redox Proteins at Solid Electrodes. \$20,000 (one year).

Paul D. Heideman, College of William and Mary. Individual Variation in a Neuroendocrine Pathway. \$17@753 (one yea@).

Stanton F. Hoegerman and William G. Kearns, College of William and Mary. Determining the Biological Relationships between Male Infertility and Chromosome Abnormalities seen at Meiosis and in Sperm Cells using Fluorescent *in situ* Hybridization. \$20,641 (one year).

Julia W. P. Hsu, University of Virginia. Spatially Resolved Optical and Transport Properties of Compound Semiconductor Thin Films and Devices. \$10,000 (one year renewal).

Robert Hull , University of Virginia. Development of a New Technique for Nanometer-Scale Mapping of Dopant Distributions in Semiconductor Structures and Devices. \$15,568 (one year).

Xi Jiang , Eastern Virginia Medical School. Genetic and Antigenic Characterization of Sapporo-like Calciviruses. \$19,066 (one year).

David N. Karowe, Virginia Commonwealth University. The Impact of Increasing Atmospheric Carbon Dioxide Within Two Multiple Trophic Level Systems. \$ 10,495 (one year).

Richard M. Kliman, Radford University. Genealogical analysis of species formation in the *Drosophila simulans* species complex. \$15,918 (one year).

Sarah E. Kruse, College of William and Mary. Near-Surface Deformation Associated with the Terrace Zone of the Chesapeake Bay Impact Structure. \$15,072 (one year).

Susan E. Lanzendorf, Eastern Virginia Medical School. In Vitro Maturation of Cynomolgus Monkey Oocytes. \$10,000 (one year renewal).

Richard T. Marconi, Virginia Commonwealth University. Analysis of the role of circular plasmid encoded gene products on the pathobiology of the Lyme Disease spirochetes. \$11,895 (one year).

G. Paul Matherne, University of Virginia. Overexpression of Myocardial A1 Receptors. \$11,988 (one year).

Marcia J. McDuffie, University of Virginia. Genetic Basis of Diabetes in NOD Mice. \$20,000 (one year).

Ravinder K. Mittal, University of Virginia. Identification of Enteric Sensory Neurons in the Small and Large Intestine. \$19,416 (one year).

Suzanne M. Moenter, University of Virginia. Synchronization of Gonadotrophin Releasing Hormone Neurons. \$20,991 (one year).

Sergio Oehninger and Ke-Wen Dong, Eastern Virginia Medical School. Expression and Characterization of Human Zona Pellucida Protein 3. \$11,073 (one year renewal).

David P. Pappas, Virginia Commonwealth University. Magnetism of ultra-thin rare earth metal films and multilayers. \$9,796 (one year).

Russell L. Prewit, Eastern Virginia Medical School. Pressure-Induced Hypertrophy in Small Artery Explants. \$19,949 (one year).

Dorothy Silver Reilly, College of William and Mary. Molecular Biology of the *Xenopus laevis* ORCL-1 Homologue Gene. \$18,155 (one year).

Christopher Rembold, University of Virginia. Cyclic AMP Mediated Relaxation of Arterial Smooth Muscle. \$20,000 (one year).

Winston Roberts, Old Dominion University. Theoretical Aspects of Baryon Spectroscopy at the Continuous Electron Beam Accelerator Facility. \$12,944 (one year).

James K. Roche, University of Virginia. Gut-derived T Lymphocytes for Regulation of the Immune Response. \$18,600 (one year).

James R. Roesser, Virginia Commonwealth University. Tissue-Specific Regulation of Alternative RNA Splicing. \$10,000 (one year renewal).

Paul K. Ross, Virginia Commonwealth University. Synthesis and Spectroscopic Characterization of Models for Nickel-Containing Metalloenzymes. \$10,000 (one year renewal).

Barbara A. Siles , College of William and Mary. The Characterization of Heterogeneous Agarose/Hydroxyethyl Cellulose Matrices for the Separation of DNA Fragments Using Capillary Electrophoresis. \$16,405 (one year).

Christopher L. Stevenson, University of Richmond. Remote Monitoring of Phytoplankton using Laser-Excited Synchronous Fluorescence and Factor-based Calibration. \$11,000 (one year).

Ann E. Sutherland, University of Virginia. Transcriptional Control of Integrin @1 Subunit Gene Expression in Mouse Embryo Trophoblast Cells. \$14,990 (one year).

Michael P. Timko and Barbara J. Mann, University of Virginia. Production of Recombinant Galactose-Inhibitable Adhesin from *Entamoeba histolytica* in Transgenic Plants: Potential for an Edible Oral Vaccine. \$20,000 (one year).

Brian M. Tissue, Virginia Polytechnic Institute and State University. Laser Spectroscopy of Probe Ions at Interfaces. \$10,018 (one year renewal).

David T. Vandermolen, Virginia Commonwealth University. Interleukin-1 Regulation of Human Endometrial Expression of the Leukemia Inhibitory Factor Family of Implantation Cytokines. \$9,800 (one year).

Mary Kate Worden, University of Virginia. Determination of Quantal Docking and Fusion. \$16,274 (one year).

Donald R. Young, Virginia Commonwealth University. Interacting Biotic Mechanisms that Control Shrub Establishment on Atlantic Coast Barrier Islands. \$14,410 (one year).

Allan A. Yousten, Virginia Polytechnic Institute and State University. Molecular Systematics of the Insect Pathogen, *Bacillus popilliae*. \$10,260 (one year).

**THE BARBARA J. HARVILL BOTANICAL
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Small research grants for floristic field work in Virginia and/or travel to herbaria are available to botanists without an institutional base of support for such work. This fund was endowed by friends and family of the late Barbara J. Harvill to encourage floristic and revisional work in Virginia. Most awards requested to date have been for mileage costs, but other expenses, such as lodging and certain kinds of field equipment (plant presses, for example) can also be covered.

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Three complete copies of each manuscript and figures are required. It is also suggested that authors include a 5.25 diskette in IBM compatible format containing a text file (ASCII) of the manuscript. Original figures need not be sent at this time. Authors should submit names of three potential reviewers. All manuscripts must be double-spaced. **Do not use special effects such as bold or large print.**

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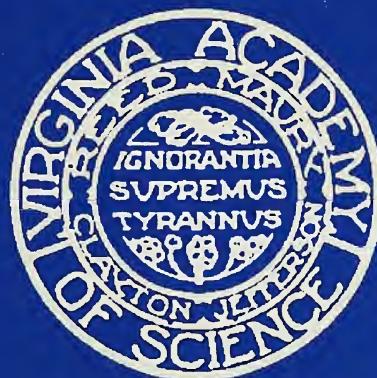
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As a direct result of Academy leadership, the state park service was established; the Virginia Institute for Scientific Research, regarded by many as a precursor to the Virginia Center for Innovative Technology, was built; and the Science Museum of Virginia was founded due to our effort to establish a statewide network of science museums. The Academy conducted the first comprehensive multidisciplinary study of the James River Basin, a publication supported by funding from the General Assembly, and assisted state agencies in responding effectively to the Kepone disaster. Since the Scopes Trial, we have fought for excellence in Virginia's science classrooms and, from our inception, have worked to ensure the quality of Virginia's environment and economic resources. We are committed to fostering the civic, academic, agricultural, industrial, and commercial welfare of

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The Virginia Academy of Science enjoys a distinguished history and tradition of ensuring the vitality and excellence of scientific research and science education in The Commonwealth of Virginia. In an increasingly complex world of global market competitiveness, threats to ecology and health, and the demanding issues of social intolerance and illiteracy; it is our conviction that the solutions necessary to resolve such challenges depend on the effective and efficacious research, teaching, and discipline of thought and action inherent in the sciences and technologies. We, therefore, rededicate ourselves to the principle reason for our existence...the pursuit of our purposes for the benefit of the people of Virginia.

The Virginia Academy of Science acknowledges our sincere appreciation to those individual, institutional, and corporate citizens who have allied themselves with our cause. Without their constant and ready support, we would be unable to execute our outstanding nationally recognized research and educational programs in service to The People of Virginia. In particular, we recognize here **The Patrons of The Academy** who have generously contributed \$1,000 or more in 1994...

Virginia Power

The Virginia Environmental Endowment

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We also note for the reader's attention those pages hereinafter listing our Individual and Institutional Sustaining Members, Business Members, Contributing Business Members, and Sustaining Business Members...

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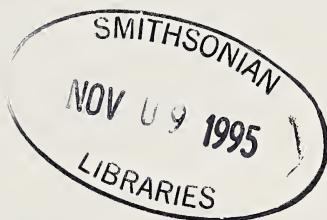
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CONSTITUTION OF VIRGINIA ACADEMY OF SCIENCE

ARTICLE I: NAME

The name of this organization shall be the Virginia Academy of Science.

ARTICLE II: PURPOSE

The purpose of this organization shall be to establish and maintain in Virginia for scientific and educational purposes an association of persons and organizations interested in science and scientific research in all of its branches; to solicit financial and other support; to cooperate with educational institutions, industries, and state agencies in fostering an interest in scientific matters, in promoting scientific investigations and in spreading knowledge of the sciences; to provide a forum for the presentation and discussion of papers on scientific subjects and facilities for their publication; to provide opportunities for the cooperation and fellowship among its members; and generally, in doing these things, to benefit not only its own members, but to promote the civic, agricultural, academic, industrial, and commercial welfare of the people of Virginia.

ARTICLE III: ORGANIZATION

Section 1. Membership

Membership in this organization shall be open to professional scientists of all branches of science and others who are interested in the purpose of the organization. Types of membership and dues for each shall be specified in Academy Bylaws. The membership, through the Academy Conference, provided by Section 2 of Article VIII, shall have ultimate authority over the affairs of this organization.

Section 2. Sections

The Academy shall be organized into Sections according to the various scientific disciplines. A person may belong to one or more Sections in accordance with his or her interests.

Section 3. Council

The governing body of this organization shall be the Academy Council. Its composition and responsibilities are specified in Article VII.

Section 4. Officers

The elected officers of this organization shall be a President, a President-Elect, a Vice President, a Secretary, and a Treasurer. Duties of each shall be specified in Academy Bylaws.

Section 5. Executive Committee

The elected officers, the immediate past president and the Director of the Junior Academy of Science shall comprise the Executive Committee of the Academy Council.

Section 6. Standing Committees

The primary activities of this organization shall be implemented by Standing Committees as follows: the Research Committee, the Long Range Planning Committee, the Junior Academy of Science Committee, the Membership Committee, the Finance and Endowment Committee, the Trust Committee, the Publications Committee, the Awards Committee, the Fund Raising Committee, the Nominations and Elections Committee, the Virginia Flora Committee, the Science Advisory Committee, the Science Education Committee, the Archives Committee, the Committee on the Environment, and the duties of the Standing Committees not specified hereafter, shall be as specified in the Academy Bylaws, and as may be further enumerated by Council from time to time.

ARTICLE IV: THE VIRGINIA JOURNAL OF SCIENCE

The Virginia Journal of Science shall be the official publication of the Virginia Academy of Science. All Academy members shall receive copies of this publication.

ARTICLE V: FELLOWS

From active membership, there shall be a body of scholars known as "Fellows of the Virginia Academy of Science" selected because of their contribution to science in one or more of the following ways: (a) outstanding scientific research, (b) inspirational teaching of science, (c) significant leadership in the Academy. Rules and procedures for selection of Fellows shall be specified in the Academy Bylaws.

ARTICLE VI: ACCREDITATION OF MEMBERSHIP

Membership of the Academy shall be accredited by the Secretary and the Treasurer. The membership list shall be published periodically according to types, as directed by Council.

ARTICLE VII: COMPOSITION AND RESPONSIBILITIES OF COUNCIL

Section 1. Council shall be composed of the President, the President-Elect, the Vice President, the Secretary, the Treasurer, the three most recent Past Presidents and one member elected by each Section of the Virginia Academy of Science. Members from the Sections shall be elected for three year terms on a rotational basis among the Sections, provided the initial term of a member from a newly established Section shall be specified by Council. In addition to the foregoing, the Chairs of the Standing Committees, the Editor of *The Virginia Journal of Science*, the Editor of *Virginia Scientists*, the official Academy Representative to the Board of Trustees of the Science Museum of Virginia, the official representative of the Academy to the American Association for Advancement of Science and National Association of Academies of Science, the Director of the Visiting Scientists Program, and the Director of the Virginia Junior Academy of Science shall be members of Council. In event of vacancies, the President shall make interim appointments until the next election is held; provided however, vacancies of elected officers shall be filled as hereafter provided.

Section 2. Council shall meet each year preceding the annual meeting and at least once in the fall at a time and place designated by the President.

Section 3. Twelve members shall constitute a quorum for the transaction of business by Council.

Section 4. Council shall establish the policies of this organization and shall be responsible for the administration of all Academy funds.

Section 5. Council shall consider and recommend to the membership from time to time appropriate changes in the Constitution, and shall promulgate bylaws appropriate to the implementation of the Constitution.

Section 6. Council may establish appropriate administrative positions and employ such personnel as may be required. Terms of office, the duties and remuneration of such personnel shall be prescribed by Council.

Section 7. Through appropriate Bylaws, Council shall provide for the publication of *The Virginia Journal of Science* and the *Virginia Scientists*.

Section 8. The Executive Committee of Council shall be empowered to act for Council on an interim basis between meetings of Council and shall report to Council at its regular meetings. A meeting of Council may be called at any time upon concurrence of any four members of the Executive Committee.

ARTICLE VIII: MEETINGS AND BUSINESS

Section 1. The annual meeting of this organization shall be arranged in accordance with procedures to be established by Council in appropriate Academy Bylaws.

Section 2. All business requiring action by the membership shall be transacted at an Academy Conference, which shall be scheduled by Council during the annual meeting. A meeting of the Academy Conference may be called between Annual Meetings by concurrence of a majority of the members of Council; provided, however, that the membership shall be notified of such called meeting no less than thirty (30) days prior to the date that such meeting is to be held. Forty accredited members shall constitute a quorum for the transaction of business by an Academy Conference.

Section 3. Each Section shall annually arrange a program oriented to its area of scientific interest; provided, however, such programs shall be compatible with the purpose of the Academy and scheduled within the framework of the general meeting program of the Academy.

Section 4. The fiscal year of the Academy shall be from January 1 through December 31.

Section 5. The parliamentary procedure for all meetings of this organization shall be governed by Robert's Rules of Order Revised, and Council shall provide for a Parliamentarian.

ARTICLE IX: ESTABLISHMENT OF SECTIONS

Section 1. Sections as defined in Article III with the approval of Council, may be organized by an accredited group of members. Each Section shall annually arrange a scientific program related to its area of interest.

Section 2. Such a Section may become accredited and established after it has conducted one successful program at an annual meeting of the Academy.

Section 3. Any Constitution and Bylaws changes proposed by a Section must conform to the provisions of the Academy Constitution and Bylaws and shall be submitted to Council for review and approval prior to adoption by Section.

Section 4. Any Section which fails to conduct a program at two successive Academy annual meetings, may be dropped as a Section by action of Council; but, may be reinstated after subsequently conducting one successful program.

Section 5. When established, all Section names shall be enumerated in the Academy Bylaws, and thereby subject to provisions of Article XIII, Section 1.

ARTICLE X: ELECTION OF ACADEMY AND SECTION OFFICERS

Section 1. A "Nominations and Elections Committee" consisting of three recent Past Presidents, appointed by the President, shall establish a slate of nominations for the positions of President-Elect, Vice President, Secretary, and Treasurer and conduct an election for same in accordance with procedures specified by Academy Bylaws.

Section 2. Upon election, officers shall serve one-year terms commencing at the annual meeting at which their election is announced and continuing until the next annual meeting; provided, however, the President-Elect shall automatically ascend to the position of President at the end of this scheduled term of office and at any prior time that the office of President may be vacated; however, such person shall not serve as President beyond the term that such person was originally scheduled to serve as President.

Section 3. All interim vacancies in Academy offices, other than President, occurring between annual Academy Conferences, shall be filled by Council from names of persons recommended by the Executive Committee. Persons so selected shall serve until the next Academy Conference.

Section 4. Each Section shall elect from their members:

- A. A Chair and a Secretary for one-year terms of office.
- B. A Representative to Council in accordance with the provisions of Article VII.
- C. Other officers desired.

Section 5. Persons to fill vacancies in Section offices which occur between Annual Meetings shall be designated by the Council Representative from that Section.

Section 6. All Elected officers shall serve without remuneration, but, at the discretion of Council, may be reimbursed for certain expenses incurred in conducting the business of the Academy.

ARTICLE XI: COMMITTEE STRUCTURE, APPOINTMENTS, TERMS, ETC.

Section 1. Except as provided otherwise, all Standing Committees shall be composed of three (3) or more members, and the President shall designate Committee Chairs, and appoint approximately one-third of the members of each Committee for terms of three (3) years, and shall subsequently appoint members to fill unexpired terms that occur periodically.

Section 2. The Research Committee shall be composed of five (5) members, each appointed for a term of five (5) years. One new member shall be appointed each year by the President to replace the member whose term expires; unexpired terms shall also be filled by appointment by the President. The senior member of the Committee shall be Chair.

Section 3. A Trust Committee, composed of three (3) accredited members, shall be elected by Council, to serve for terms of three (3) years on a rotational basis. The members of this Committee shall place in trust and supervise the management of Academy investments subject to annual review by Council. The Committee shall elect its own Chair; provided, however, that should it be unable to do so, the President shall name the Chair.

Section 4. The President and Council shall assign operational matters to appropriate Standing Committees; however, the President and/or Council may establish Special Committees as the need arises.

ARTICLE XII: JUNIOR ACADEMY OF SCIENCE

The Academy shall provide financial support, leadership, and supervision to a Junior Academy of Science. Effective working relationships shall be maintained with such Junior Academy of Science, through the Junior Academy of Science Committee.

ARTICLE XIII: BYLAWS AND AMENDMENTS

Section 1. Council shall promulgate appropriate Bylaws to implement or further clarify the Articles of this Constitution. The establishment or amendment of such Bylaws shall require an affirmative vote of a majority of the total membership of Council; provided, that all proposed Bylaws or amendments shall be distributed to the membership or published in an issue of *The Virginia Journal of Science* at least thirty (30) days prior to action by Council.

Section 2. This Constitution may be changed or amended, after the recommendation of a majority of the total membership of Council, by a two-thirds majority of an Academy Conference, provided all proposed changes shall be submitted to members of Council in writing no less than fifteen (15) days prior to the Council Meeting at which such proposals are to be considered and further provided that subsequent to approval by Council, all proposed amendments shall be published in *The Virginia Journal of Science* or distributed in writing to the membership no less than twenty five (25) days nor more than fifty (50) days prior to presentation to an Academy Conference for adoption.

Section 3. All provisions of the Constitution and Bylaws in effect prior to the adoption of this Constitution, except the provisions of this Article, shall rule until new Bylaws are duly established in accordance with Section 1 of this Article.

ARTICLE XIV: ARTICLES OF INCORPORATION

The Articles of Incorporation of this organization (Charter) shall conform to the provisions of this Constitution and all amendments hereafter adopted. The Constitution and Bylaws Committee shall review and coordinate all necessary appropriate revisions of both documents and be responsible for the submission of all required reports to the State Corporation Commission and other governmental entities, annually or as otherwise required by law.

ARTICLE XV: DISSOLUTION OR LIQUIDATION

Section 1. In the event of dissolution or liquidation, all liabilities and obligations of the Academy shall be paid, satisfied and discharged.

Section 2. All assets remaining, including those received and held for scientific and educational purposes, shall be transferred to one or more societies or organizations engaged in activities substantially similar to those of the Academy; provided however, that no assets shall accrue to the benefit of any officer or member of the Academy.

BYLAWS OF VIRGINIA ACADEMY OF SCIENCE

ARTICLE I: TYPES OF MEMBERSHIP AND DUES

Section 1. There shall be nine types of members: regular, student, contributing, sustaining, life, patron, honorary life, business, and emeritus.

Section 2. Dues of the first four types of members shall be as follows:

- A. Regular members shall pay annual dues of twenty-five dollars (\$25.00).
- B. Student members shall pay annual dues of ten dollars (\$10.00).
- C. Contributing members shall be individuals who elect to pay annual dues of thirty dollars (\$30.00).
- D. Sustaining members shall be individuals who elect to pay annual dues of fifty dollars (\$50.00) or more, and institutions which shall pay annual dues of one hundred dollars (\$100.00) or more.
- E. To be in good standing the foregoing types of members must pay the specified dues by July 1.

Section 3. Life members shall be individuals who elect to pay to the Academy the sum of five hundred dollars (\$500.00) and thereby become exempt from further payment of dues.

Section 4. Patrons shall be those persons who have given to this organization the sum of one thousand dollars (\$1,000.00) or its equivalent in property. They shall have all the rights and privileges of membership for one year. An institution may also become a Patron by meeting the above requirement. Its representative shall have all the rights and privileges of regular members.

Section 5. Honorary Life members shall be persons elected by the Council for long and distinguished service to science. They shall have all the rights and privileges of Regular Members and shall be exempt from dues. Previous active membership in this organization shall not be a requirement of eligibility.

Section 6. Business or industrial organizations, which elect to pay dues of one hundred dollars (\$100.00) annually, shall be Regular Business Members of the Academy, or may elect to:

- A. Pay annual dues of three hundred dollars (\$300.00) and be designated Contributing Business Members, or
- B. Pay annual dues of five hundred dollars (\$500.00) and be designated Sustaining Business Members.

Section 7. Emeritus Members shall be persons who have been active Academy members for at least ten years and retired from full-time employment. These Members shall have all rights and privileges of regular membership but will be exempt from dues. Eligibility for Emeritus membership status will be determined by requests to the Membership Committee.

ARTICLE II: DUTIES OF OFFICERS

Section 1. The President shall be the directing head of the Academy, shall preside at business meetings and general sessions of the organization, and shall appoint the members of the standing committees and of new committees authorized by the Council, in accordance with Article XI of the Constitution.

Section 2. The President-Elect shall assist the President as mutually agreed between them and shall serve as President in the latter's absence. The President-Elect shall furnish the Editor of *The Virginia Journal of Science*, in time for publication with the Summer issue of *The Virginia Journal of Science*, a list of committee memberships which he or she has set up to assist him or her during his or her year as President. The President-Elect shall distribute that list to Council at the Annual Meeting at which he or she automatically ascends to President. The President-Elect begins a three year term serving as a member of the Finance and Endowment Committee.

Section 3. The Vice President shall be responsible for coordinating the scientific programs of the Annual Meeting. The Vice President shall serve as a member of the Membership Committee.

Section 4. The Secretary shall be responsible for keeping complete records of the Academy Conference and all meetings of the Council and Executive Committee.

Section 5. The Treasurer shall:

- A. Account for the income and disbursements through one Academy General Fund Account.
- B. Keep the membership lists of the Academy up-to-date.
- C. Upon request, supply the Secretary and others a list of all members in good standing.
- D. Receive and disburse all funds as approved by Council and directed by the President or Chair of the Finance Committee and Endowment Committee.
- E. Submit to Council annually a written report of all receipts and disbursements, accompanied by a statement of audit from a certified public accountant.

- F. Furnish quarterly financial summaries to the Executive Committee, members of Council, and to members of the Finance Committee.
- G. Prepare annually and present to the Finance and Endowment Committee for review a proposed budget for Academy operations.

Section 6. The Treasurer and all administrative employees engaged in the receipt and disbursement of funds shall be adequately bonded.

Section 7. All officers shall be ex-officio members of all Academy Committees.

ARTICLE III: DUTIES OF STANDING COMMITTEES

Section 1. The Research Committee shall:

- A. Review and award Academy Research Grants.
- B. Arrange for and present the J. Shelton Horsley Research Award.

Section 2. The Long Range Planning Committee shall:

- A. Develop and advise Council on broad policies which will affect the Academy in the future.
- B. Solicit and study suggestions from the membership for the improvement of Academy activities.
- C. Investigate and evaluate proposed projects, publications and other factors that may relate to the long-range effectiveness of the Academy.
- D. Advise and consult with other Academy Committees relative to the foregoing and make recommendations to such committees concerning the effectiveness of their various activities.

Section 3. The Junior Academy of Science Committee of the Virginia Academy of Science shall:

- A. Assist the Executive Committee in selecting a Director and an Associate Director for the Virginia Junior Academy of Science.
- B. Coordinate with the Director activities of The Virginia Junior Academy of Science including development, expansion, and the annual meetings.
- C. Review funding proposals for the Virginia Junior Academy of Science and submit appropriate recommendations to the Executive Committee or other designated committees in a timely manner.
- D. Publish and distribute *Proceedings of Virginia Junior Academy of Science*.
- E. Select student representatives and alternates to attend The American Junior Academy of Science.
- F. Solicit membership and participation in Virginia Junior Academy of Science programs and projects.
- G. Support and participate in all other programs and activities related to the work of Virginia Junior Academy of Science.

- H. Set up procedures for selecting the top students and declare and announce them to be State Winners in the Virginia Science Talent Search, and all other contestants as runners-up.
- I. Carry out other duties that support the development of science in education as approved by Council.

Section 4. The Membership Committee shall:

- A. Make recommendations to Council, the Executive Committee and officers relative to policies on general membership.
- B. Promote membership growth and seek adequate representation from all scientific disciplines.
- C. Sponsor a Business Advisory Committee for the purpose of creating understanding between science and business, and to solicit business memberships to the Academy.

Section 5. The Finance and Endowment Committee shall:

- A. Monitor and appraise income and expenditures, and make appropriate recommendations to the President, Executive Committee and Council.
- B. Estimate annually the anticipated income of the Academy and prepare a proposed budget for consideration by Council at its Fall meeting.
- C. Seek and encourage the establishment of endowments to the benefit of Academy activities.
- D. Have at least one member of this Committee be a member of the Trust Committee.

Section 6. The Trust Committee shall:

- A. Place in trust and supervise the management of funds of the Academy designated by Council or otherwise for investment.
- B. Review all Academy investments annually and make appropriate adjustments subject to approval of Council.

Section 7. The Publications Committee shall:

- A. Develop and implement a continuing policy of review and evaluation of Academy publications.
- B. Present to Council annually through the Finance Committee the budgetary needs of the several Academy periodical publications.
- C. Make recommendations to Council relative to priority, publication, finance and distribution of non-recurring publications.
- D. Select and recommend to Council, as necessary; an Editor for the *Virginia Journal of Science*, and members of the editorial Board.
- E. Enlist the interest of all groups in worthwhile publications by the Academy.

Section 8. The Awards Committee shall:

- A. Select recipients of the Ivey F. Lewis Distinguished Service Award to be presented periodically to a member who has made significant contributions toward the activities of the Virginia Academy of Science.
- B. Select recipients of Special Awards periodically as directed by Council.
- C. Accept and submit to Council nominations for fellows in accordance to Article V of the Constitution and Article V of the Bylaws.

Section 9. The Fund Raising Committee shall:

- A. From time to time at the direction of Council, plan, organize, and coordinate appropriate fund raising campaigns in support of Academy activities or projects contingent to the purposes of the Academy.

Section 10. The Nominations and Elections Committee shall:

- A. Mail to the membership on or about January 1 each year a request for nominations of persons to fill the offices of President-Elect, Vice President, Secretary and Treasurer.
- B. Nominate a slate of one person for each of the aforementioned offices and present report to Council for informational purposes.
- C. Mail slate of nominees to members advising that names may be added to the slate by 25 members petitioning the committee on behalf of each name to be added.
- D. Prepare ballots with or without additional nominees as the case may be and mail to membership with registration and other information relative to annual meeting indicating deadline and address for return of ballot to committee.
- E. Count ballots and announce results at the Academy Conference. Should a tie vote result for any office, the Academy Conference shall vote on the nominees. In all cases, the nominee receiving the largest number of favorable votes shall be elected; provided, however, that only members in good standing may cast ballots.

Section 11. The Constitution and Bylaws Committee shall:

- A. Periodically receive and prepare drafts of all proposed changes in constitution as the occasion arises and present same to Council and membership for consideration as set forth in the constitution.
- B. Draft all Bylaw changes as directed by Council and notify membership of such changes.
- C. Update articles of Incorporation (Charter) as required.
- D. Provide a Parliamentarian for all Council meetings and Academy Conferences.

Section 12. The Virginia Flora Committee shall:

- A. Promote the study of and publications of the flora and vegetation of Virginia.
- B. Sponsor symposia and conferences on the ecology, conservation, and preservation of the plant life of Virginia.
- C. Disseminate botanical information to all who are interested in the flora and ecology of Virginia.
- D. Serve as liaison between the Academy, government bodies, and institutions in matters pertaining to the plant life of Virginia.

Section 13. The Science Advisory Committee Shall:

- A. Provide scientific and technical information and advice requested by the Executive, Legislative, and other governmental bodies and agencies of the Commonwealth of Virginia.
- B. Serve as liaison for the collection and transfer of scientific information and/or advice solicited in (A).
- C. Collect and evaluate suggestions and opinions regarding topics of general public interest wherein science and technology may provide assistance, but where such assistance has not been requested. The Science Advisory Committee will make recommendations to the Academy, to the Executive Committee, and/or the Council of the Academy for review and approval. The Science Advisory Committee, upon direction of Council or Executive Committee, shall serve as a conduit for placement of such information before the appropriate Executive, Legislative, or other governmental body or agency.
- D. Maintain an inventory of scientific interests and expertise of individuals within the Academy who are willing to serve in an advisory and/or consultant capacity to state government.
- E. At no time operate beyond constraints considered as proper conduct for a non-profit organization.
- F. Append all reports and recommendations with a statement as follows; "The Virginia Academy of Science assumes no legal or financial responsibility for the utilization or dispersal of scientific and technical data or advice provided by the science Advisory Committee, further, the Academy assumes no responsibility, financial or other-wise, to governmental agents or agencies, institutions, individuals or committee members pursuant to the conduct and activities of this Committee."

Section 14. The Science Education Committee shall:

- A. Promote science education in the State of Virginia.
- B. Disseminate information about scientific matters and scientific topics of current interest.
- C. Respond to requests for assistance in matters dealing with education in the areas of mathematics and science, such as are embraced by the

various Academy Sections and as directed by the President and Council of the Academy.

- D. Assist and cooperate with the Virginia State Department of Education in planning and conducting the annual State Science Teachers Conference, K-12. Delegated members of the Committee may hold and be responsible for funds generated by the activities of the State Science Teachers Conference, solely for the purpose of funding the Conference meetings. These funds shall remain separate from other funds of the Academy.

Section 15. The Archives Committee shall:

- A. Address the business of collection, assembly, organization, cataloguing and storage of records, documents, awards and paraphernalia associated with the history and development of the Academy.
- B. Secure an institutional repository for storage of the inactive records of the Academy.
- C. Secure the services of a qualified individual to establish and maintain the aforementioned records, as the official Archivist of the Academy; and such person shall be extended honorary membership in the Academy.
- D. Assist, and cooperate, with the Archivist in securing and screening of records and documents destined for permanent storage in the Archives.

Section 16. The Committee on the Environment shall:

- A. Maintain close liaison with organizations and agencies involved in environmental study and management.
- B. Keep informed of the status of Virginia's environment, noting particularly those problems and issues amenable to scientific research.
- C. Cooperate with the Science Advisory Committee in advising and providing information to private and public environmental agencies and bodies.

ARTICLE IV: THE VIRGINIA JOURNAL OF SCIENCE

Section 1. The Academy shall publish *The Virginia Journal of Science* quarterly.

Section 2. The staff of *The Virginia Journal of Science* shall be composed of:

- A. An editor recommended by the Publications Committee and appointed by Council for a three-year term.
- B. Such Associate Editors, Assistant Editors, or Editorial Board Members, appointed by the President, as are recommended by the Editor and the Publications Committee.
- C. Editors designated by individual Sections.

Section 3. All members of the Academy shall receive *The Virginia Journal of Science*.

Section 4. Subscriptions may be sold to non-members at a rate established by the Publications Committee and approved by Council.

ARTICLE V: RULES AND PROCEDURES FOR SELECTING FELLOWS

Section 1. A Fellow must be nominated by at least three members of the Academy. The Academy Council must approve each Fellow by a majority vote. It will be the usual procedure to announce new Fellows at an Annual Meeting.

Section 2. Nominations for Fellows with appropriate biographical information shall be sent directly to the Executive Secretary-Treasurer annually prior to October 1. All information received shall be forwarded to the Chair of the Awards Committee for review and recommendations to Council prior to the subsequent Annual Meeting. All nominees not recommended by the Committee or not acted upon favorably by Council shall remain in consideration for one additional year.

Section 3. No more than twenty-five fellowships will be approved the first year. After the first year, no more than one-half of one percent of the total active membership shall be selected in any one year. The limiting number of Fellows shall not exceed five percent of the total active membership of the Academy. However, nothing in this section shall preclude the election of one Fellow each year.

Section 4. All Fellows shall be presented with a suitably inscribed scroll.

Section 5. Appropriate announcement of new Fellows shall be made in *The Virginia Journal of Science*.

ARTICLE VI: THE DULY ORGANIZED SECTIONS OF THE ACADEMY

The duly organized scientific sections of the Academy are:

- (1) Agriculture, Forestry, and Aquaculture
- (2) Astronomy, Mathematics, and Physics
- (3) Microbiology and Molecular Biology
- (4) Biology
- (5) Chemistry
- (6) Materials Science
- (7) Biomedical and General Engineering
- (8) Geology
- (9) Medical Sciences
- (10) Psychology
- (11) Education
- (12) Statistics
- (13) Aeronautical and Aerospace Sciences
- (14) Botany
- (15) Environmental Science
- (16) Archaeology
- (17) Computer Science
- (18) Geography
- (19) Natural History and Biodiversity

ARTICLE VII: OFFICIAL REPRESENTATION OF THE ACADEMY

Section 1. Where official representation of the Academy is desirable, the President, the President's designees, or an official representative appointed by Council shall represent The Academy.

Section 2. No Officer or Academy Member shall receive reimbursement from Academy funds for such purposes except as included in the annual budget of the Academy or separately approved by Council from available funds.

Section 3. The official representative to serve as delegate to the American Association for the Advancement of Science (AAAS) shall be appointed by Council for a term designated by the AAAS. Actual expenses of the official representative in attending the Annual Meeting of AAAS may be paid if the funds are included in the budget or separately approved by Council.

Section 4. The official representative to serve on the Board of Trustees of the Science Museum of Virginia shall be recommended by Council and serve as an ex officio member of Council. Actual expenses of the official representative may be paid if the funds are included in the budget or separately approved by Council. Expenses payable by the Board or Science Museum of Virginia shall not be reimbursed by the Academy.

ARTICLE VIII: MEETINGS AND BUSINESS

The annual meeting of this organization shall be held in the Spring of each year at a time and place selected by Council, which shall arrange for all appropriate sessions.

ARTICLE IX: EXECUTIVE SECRETARY-TREASURER

Section 1. The position of Executive Secretary-Treasurer is hereby established for the purpose of providing administrative assistance to the officers and committee chairs.

Section 2. The Executive Committee shall select a qualified person for this position, specify his or her duties, and set appropriate remuneration which shall be approved by Council.

Section 3. The incumbent of this position shall serve at the pleasure of the Executive Committee, subject to review by Council.

Section 4. The incumbent of this position shall attend all Council and Executive Committee Meetings and may participate in all deliberations as circumstances dictate, but, shall not have a vote in either body.

ARTICLE X: VISITING SCIENTISTS PROGRAM DIRECTOR

Section 1. The position of Visiting Scientists Program Director is hereby established for the purpose of implementing a Visiting Scientists Program in cooperation with the State Board of Education.

Section 2. The Executive Committee upon recommendation of the President shall select a qualified person for this position and approve guidelines for the conduct of the program.

Section 3. The incumbent of this position shall serve at the pleasure of the Executive Committee, subject to review by Council.

ARTICLE XI: THE DIRECTOR OF THE VIRGINIA JUNIOR ACADEMY OF SCIENCE

Section 1. The position of Director of the Virginia Junior Academy of Science is hereby established for the purpose of providing leadership, supervision, and administrative support to the Virginia Junior Academy of Science and the Junior Academy of Science Committee.

Section 2. The Executive Committee, subject to the approval of Council, shall select a qualified volunteer for this position.

Section 3. The incumbent of this position shall serve at the pleasure of the Executive Committee subject to review by Council.

Section 4. Duties of the Director of the Virginia Junior Academy of Science.

- A. The Virginia Junior Academy of Science Director shall provide leadership, supervision and administrative support to the Virginia Junior Academy of Science.
- B. The Virginia Junior Academy of Science Director shall be a member of The Virginia Academy of Science, shall attend all Council and Executive Committee meetings and may participate in all deliberations.
- C. The Virginia Junior Academy of Science Director shall prepare an annual budget for the Virginia Junior Academy of Science and submit the Virginia Junior Academy of Science budget with Virginia Junior Academy of Science Committee recommendations to the Academy Finance and Endowment Committee by September 1.
- D. The Virginia Junior Academy of Science Director shall coordinate all fund raising by the Virginia Junior Academy of Science with the Fund Raising Committee, The Trust Committee, and The Finance and Endowment Committee.
- E. The Virginia Junior Academy of Science Director shall be responsible for the program of Virginia Junior Academy of Science at the annual meeting of the Academy and coordinate Virginia Junior Academy of Science activities with the Virginia Academy of Science Program Chair.
- F. The Virginia Junior Academy of Science Director shall be responsible for the development and expansion of the Virginia Junior Academy of Science as approved by Council.
- G. The Virginia Junior Academy of Science Director shall serve as Chair of the Junior Academy of Science Committee with the approval of the President.
- H. The Virginia Junior Academy of Science Director shall carry out other duties specified by the Virginia Junior Academy of Science Committee or the Executive Committee as approved by Council.

ARTICLE XII: ASSOCIATE DIRECTOR OF THE VIRGINIA JUNIOR ACADEMY OF SCIENCE

Section 1. The position of Associate Director of the Virginia Junior Academy of Science is hereby established for the purpose of providing administrative assistance to the Junior Academy of Science Committee, the Chair of the Junior Academy of Science Committee and the Director of the Virginia Junior Academy of Science.

Section 2. The Executive Committee, subject to the approval of Council, shall select a qualified person for the position, specify his or her duties, and set appropriate remuneration, if any.

Section 3. The incumbent of this position shall serve at the pleasure of the Executive Committee, subject to annual review by Council and by the Junior Academy of Science Committee.

Section 4. The incumbent of this position shall be a member of the Virginia Academy of Science, attend all Council meetings and all Virginia Junior Academy of Science Committee meetings, and may participate in all deliberations as circumstances dictate, but shall not have a vote in either body.

ARTICLE XIII: VIRGINIA SCIENTISTS NEWSLETTER

Section 1. The Virginia Academy of Science shall publish periodically the *Virginia Scientists* as its newsletter.

Section 2. The staff of the *Virginia Scientists* shall be composed of:

- A. An Editor recommended by the Publications Committee and appointed by Council for a three-year term.
- B. Such Associate Editors, Assistant Editors, or Editorial board Members, appointed by the President, as are recommended by the Editor.

Section 3. The Editor shall serve on the Publications Committee and on Council.

Section 4. All members of the Virginia Academy of Science shall receive the *Virginia Scientists*.

ARTICLE XIV: OFFICIAL ABBREVIATIONS

Section 1. The official abbreviation for the Virginia Academy of Science shall be **VAS**.

Section 2. The official abbreviation for the Virginia Junior Academy of Science shall be **VJAS**.

**FUTURE MEETINGS
AND
CHAIRS OF LOCAL ARRANGEMENTS COMMITTEES**

74th VAS...55th VJAS...May 21-24, 1996

Virginia Commonwealth University, Richmond, Virginia

Thomas W. Haas, Director, Cooperative Graduate Engineering Program

Virginia Commonwealth University, Richmond VA 23284-2009

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(For list of Committee Members in charge of scheduling, registration, exhibits, etc.; see **Special Committee on Local Arrangements** listings.)

75th Anniversary of The Virginia Academy of Science

56th VJAS...May 1997

Virginia Polytechnic Institute and State University

Blacksburg, Virginia

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76th VAS...57th VJAS...May 1998

George Mason University, Fairfax, Virginia

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FAX: 703-993-3193

77th VAS...58th VJAS...May 1999

Old Dominion University, Hampton, Virginia

78th VAS...59th VJAS...May 2000

Radford University, Radford, Virginia

(NOTE: Academy Central Office, Publications, and other frequently used addresses and phones are listed on the inside back cover.)

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(According to Constitution Article XI, Section 3, the Trust Committee is composed of three accredited Members and shall elect its own Chair. According to Bylaw Article III, Section 5, Paragraph D, one member of the Trust Committee is a member of the Finance and Endowment Committee; see Paul J. Homsher).

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William M. Hinton	1959-60			

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Donald R. Cottingham . . .	1991-

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James W. Cole, Jr.	1973
Vera B. Remsburg and	
E. L. "Chick" Wisman . . .	1974

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Lee S. Anthony	1977
John L. Hess	1978
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Dawn Campbell∞	1983
Bernie J. Kozakowski	1984
Dallas W. Cocke∞	1985
Eleanor Lewis Tenney ∞ . . .	1988
F. Lee Larkin and	
Lisa L. Martin	1992

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E. C. Stevenson		1931	Frank A. Vingiello
James H. Smith		1932	O. R. Rodig and
S. A. Wingard		1933	Galal Zanati
E. P. Johnson		1934	H. H. Hobbs, P. C. Holt ∞,
Margaret Hess		1935	and Margaret Walton ∞ . . .
Alfred Chanutin		1936	A. J. McCaffery, P. N. Schatz,
R. G. Henderson		1937	and T. E. Lester
S. G. Bedell		1938	I. Gordon Fels
M. J. Murray and			L. R. Durden, L. H. Slack, and
Forrest F. Cleveland		1939	P. R. Eusner
Walter C. Gregory		1940	I. J. Good and
Charles Ray		1941	R. A. Gaskins
No Award		1942	Larry Taylor, J. C. Dillard, and
J. B. Meyer		1943	J. H. Burness
J. Gerbert Taylor		1944	Kuldip P. Chopra
No Award		1945	Roddy V. Amenta
Boyd Harshbarger		1946	Douglas W. Ogle and
D. B. DeJury		1947	Peter Mazzeo
Henry Leidheiser, Jr.		1948	Henry W. Gould
Walter S. Flory		1949	K. L. Reifsnyder and
Erling S. Hegre		1950	K. D. O'Brien
D. B. Duncan		1951	William L. Dewey
D. R. H. Gourley		1952	C. R. Terman and
Stephen Burko and			R. J. Huggett
Frank L. Hereford		1953	L. E. Jarrard
Lynn D. Abbott, Jr. and			Joyce G. Foster,
Mary J. Dodson		1954	Harold E. Burkhart, and
Albert W. Lutz, Jr. and			Peter T. Sprinz
A. E. B. Reid		1955	R. W. Berlien, G. Colmano, and
M. C. K. Tweedie		1956	G. Nunn
R. A. Bradley, D.E.W. Schumann, and W. H. Lewis		1957	Milton M. Sholley,
C. Tyler Miller, Jr. and			Gilda P. Ferguson,
K. R. Lawless		1958	Hugo R. Seibel,
Dorothy L. Crandall		1959	James L. Montour, and
Lawrence I. Miller,		1960	John D. Wilson
Irving R. King, Billy W. Sloope, and Calvin O. Tiller		1961	Robert F. Johnson
			Richard B. Brandt
			Muriel Lederman
			George W. Mushrush

R. Bruce Martin	1990
W. John Hayden	1991
(not awarded)	
W. Peter Trower	1993
William P. Harrison	1994

RECIPIENTS OF THE JEFFERSON GOLD MEDAL

Alfred Chanutin	1936
William B. Porter	1937
H. M. Phillips	1938
G. M. Shear and	
H. D. Ussery	1939

RECIPIENTS OF THE JEFFERSON PRIZE

L. G. Overholzer and	
J. H. Yoe	1940
*Allan T. Gwathmey	1941
R. N. Jefferson	1942
W. H. Hough	1943
Clinton B. Cosby	1944

MERITORIOUS SERVICE AWARDS

Ivey F. Lewis ∞ and	No Award	1962
William T. Sanger ∞	Allan T. Gwathmey ∞	
No Award	Sidney S. Negus ∞ and	
American Tobacco Co.	Jesse W. Beams ∞	1963
Research Laboratory	No Award	1964
Lloyd C. Bird ∞	Hiram R. Hanmer	1965
No Award		
No Award		

∞ Deceased

IVEY F. LEWIS DISTINGUISHED SERVICE AWARDS

Boyd Harshbarger	1966	Carolina Biological Supply Company	1982
Russell J. Rowlett, Jr.	1967	No Award	1984
George W. Jeffers ∞	1968	Arthur W. Burke, Jr.	1985
Walter S. Flory, Jr.	1969	Virginia C. Ellett	1985
Roscoe D. Hughes ∞	1970	Vera B. Remsburg	1986
Horton H. Hobbs, Jr. ∞	1971	No Award	1987
No Award	1972	No Award	1988
No Award	1973	Ertle Thompson	1989
Lynn D. Abbott, Jr.	1974	Dale V. Ulrich	1990
Edward S. Harlow	1975	R. Dean Decker	1991
D. Rae Carpenter, Jr.	1976	Blanton M. Bruner	1992
No Award	1977	Harold M. Bell	1993
Rodney C. Berry ∞	1978	Virginia Power	1994
Edward F. Turner, Jr. ∞	1979	James H. Martin	1995
Ruskin S. Freer ∞	1980		
Philip Morris, Inc.			

(Presented to
Bernard Kosakowski) 1981

FELLOWS OF THE VIRGINIA ACADEMY OF SCIENCE

1970

Jesse Wakefield Beams ∞
 John Campbell Forbes ∞
 Thomas E. Gilmer ∞
 Boyd Harshbarger
 Roscoe D. Hughes ∞
 Clyde Young Kramer ∞
 J. Douglas Reid ∞
 William T. Sanger ∞

1971

Robert C. Carter ∞
 Edward S. Harlow
 Wilbert Harnsberger, Jr. ∞
 Alton M. Harville, Jr.
 Sterling M. Heflin ∞
 George W. Jeffers ∞
 Harry G. M. Jopson
 Everett L. Wisman

1972

Lynn De Forrest Abbot
 Rodney C. Berry ∞
 Lloyd C. Bird ∞
 Robert P. Carroll ∞
 James W. Cole, Jr.
 Walter S. Flory, Jr.
 Mary E. Kapp ∞
 Paul B. Siegel

1973

D. Rae Carpenter, Jr.
 Virginia C. Ellett
 Susie V. Floyd ∞
 A. B. Niemeyer, Jr.
 Edgar V. Russell, Jr. ∞
 Raymond L. Taylor

1974

Perry C. Holt
 William T. Ham, Jr.
 Leonard O. Morrow
 Robert F. Smart

1975

Franklin F. Flint ∞
 Horton H. Hobbs, Jr. ∞
 Michael Kosztarab
 Vera B. Remsburg
 William E. Trout, Jr. ∞
 W. Peter Trower
 Edward F. Turner, Jr. ∞

1976

Miles E. Hench
 Franklin D. Kizer
 Russell J. Rowlett, Jr.

1977

Bernard R. Woodson, Jr.

1978

Blanton M. Bruner
 A. W. Burke, Jr.
 Herbert McKennis, Jr. ∞
 W. Allan Powell
 Stanley Ragone ∞

1979

S. Gaylen Bradley
 Addison D. Campbell
 William M. Hinton ∞
 William L. Mengebier
 Maurice B. Rowe
 Jackson J. Taylor
 Ertle Thompson

1980

Dorothy Bliss
 Elizabeth Jackson
 Ralph A. Lowry
 James W. Midyette
 Helmut R. Wakeham

1981

Hubert J. Davis
 Frank L. Hereford
 Peter M. Mazzeo
 Warwick R. West, Jr.

1982

Dale V. Ulrich

1983

Donald G. Cochran
 Dallas W. Cocke ∞
 R. Dean Decker
 Mario R. Escobar ∞
 Charles O'Neal
 Martha L. Walsh ∞

1984

Dawn Campbell ∞
 Frank Leftwich
 J. J. Murray
 Stewart Ware

1985

Edward A. Crawford

1986

No Fellows Elected

1987

No Fellows Elected

1988

No Fellows Elected

1989

Kenneth R. Lawless

1990

James H. Martin

1991

Martha K. Roane

1992

Richard B. Brandt

1993

I. J. Good

1994

No Fellows Elected

1995

Golde I. Holtzman

Gerald R. Taylor

HONORARY LIFE MEMBERS

Rodney C. Berry ∞
 Lloyd C. Bird ∞
 Blanton M. Bruner
 Walter S. Flory
 J. C. Forbes ∞
 Edward S. Harlow
 Boyd Harshbarger
 Horton H. Hobbs, Jr. ∞
 George W. Jeffers ∞
 Mary E. Kapp ∞
 Arthur H. Livermore

A. B. Massey ∞
 Herbert McKennis, Jr. ∞
 Glenn McMullen
 Beverly Orndorff
 Russell J. Rowlett
 Myron Shear ∞
 Robert F. Smart
 I. D. Wilson ∞
 Hubert J. Davis
 Martha L. Walsh ∞

REGULAR MEMBERS

ACKERMANN, ERNEST C.	17	AMMERMAN, DON J.	02
COMPUTER SCIENCE DEPT		8384 CEDAR LANE	
MARY WASHINGTON COLLEGE		KING GEORGE, VA 22485	
FREDERICKSBURG, VA 22401-5358			
ADAMKEWICZ, LAURA	04	ANDERSON, JOHN E.	04
BIOLOGY DEPT		5 RIDGEVIEW CIRCLE	
GEORGE MASON UNIVERSITY		HARTWOOD, VA 22406	
FAIRFAX, VA 22030			
ADAMS, HAROLD S.	14	ANDERSON, SAMUEL	05
CLIFTON CIRCLE		6332 DARTMOUTH WAY	
CLIFTON FORGE, VA 24422		VIRGINIA BEACH, VA 23464	
AFFRONTI, LEWIS F. JR	15	ANDERSON, BRUCE M.	05
4316 JOHN SILVER RD		1013 HIGHLAND CIRCLE	
VIRGINIA BEACH, VA 23455		BLACKSBURG, VA 24060	
AGBE-DAVIES, ANNA S.	16	ANDRAOS-SELIK, CECILE	03
DEPT OF ARCHAEOLOGICAL RE-		BIOLOGY DEPT	
SEARCH		CHRISTOPHER NEWPORT UNIVER-	
PO BOX 1776		SITY	
WILLIAMSBURG, VA 23187-1776		NEWPORT NEWS, VA 23606	
AGRAWAL, KRISHAN M.	02	ANDREWS, ROBERT L.	12
MATHEMATICS DEPT		2018 GROVE AVE	
VIRGINIA STATE UNIVERSITY		RICHMOND, VA 23220	
PETERSBURG, VA 23806			
AITKEN, WILLIAM C. JR.	10	ANYIWO, JOSHUA C.	17
4809 BOXFORD RD		PO BOX 6376	
VIRGINIA BEACH, VA 23456		CHRISTOPHER NEWPORT UNIVER-	
ALLEN, VIVIEN G.		SITY	
2302 SLIDE RD UNIT 40		NEWPORT NEWS, VA 23606	
LUBBOCK, TX 79407-2252			
ALLEN, MILTON J.	09	ATKINS, ROBERT C.	05
BIOPHYSICAL LAB, CHEMISTRY		CHEMISTRY DEPT	
DEPT		JAMES MADISON UNIVERSITY	
1001 WEST MAIN ST, BOX 2006		HARRISONBURG, VA 22807	
RICHMOND, VA 23284			
ALTY, LISA TREVEY	09	ATKINSON, ROBERT B.	11
CHEMISTRY DEPT		CTR FOR ENVIRONMENTAL STUDIES	
WASHINGTON & LEE UNIVERSITY		VPI & SU	
LEXINGTON, VA 24450		BLACKSBURG, VA 24061-0415	
AMENTA, DONNA S.	05	AUKLAND, ELVA D.	03
110 CRESCENT DRIVE		2412 N. COLUMBUS AVE	
HARRISONBURG, VA 22801		ARLINGTON, VA 22207	
AMENTA, RODDY V.	08	AUSTIN, JOHN M.	11
110 CRESCENT DRIVE		1001 SEVENTH AVE	
HARRISONBURG, VA 22801		FARMVILLE, VA 23901	
		AUSTIN, SAMUEL H.	15
		FONTAINE OFFICE PARK	
		P.O. BOX 3758	
		CHARLOTTESVILLE, VA 22903	

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71

BAILEY, CLIFTON 6507 DIVINE ST MCLEAN, VA 22101	12	BASS, MICHAEL L. BIOLOGICAL SCIENCES DEPT MARY WASHINGTON COLLEGE FREDERICKSBURG, VA 22401	04
BAIRD, EDWARD R. JR. WILCOX AND BAIRD 210 MONTICELLO ARCADE NORFOLK, VA 23510	15	BATES, ROBERT C. BIOLOGY DEPT VPI & SU BLACKSBURG, VA 24061	03
BAIRD, J. REX BIOLOGY DEPT CLINCH VALLEY COLLEGE WISE, VA 24293	14	BAUER, DAVID F. MATH SCIENCE DEPT P.O. BOX 842014 VIRGINIA COMMONWEALTH UNIVERSITY RICHMOND, VA 23284-2014	12
BAKER, SUZANNE C. PSYCHOLOGY DEPT JAMES MADISON UNIVERSITY HARRISONBURG, VA 22807	19	BAUR, THOMAS S. BIOLOGY DEPT VIRGINIA MILITARY INSTITUTE LEXINGTON, VA 24450	04
BANKES, DAVID A. 84 MAIN ST NEWPORT NEWS, VA 23601	14	BAY, MICHAEL D. BIOLOGY DEPT AVERETT COLLEGE DANVILLE, VA 24541	04
BARBARO, RONALD D. 7036 LEE PARK COURT FALLS CHURCH, VA 22042	15	BAYLES, ROBERT A. CODE 6312 NAVAL RESEARCH LABORATORY WASHINGTON, DC 20375-5343	06
BARBER, PATRICK G. RT. 2, BOX 29-B KEYSVILLE, VA 23947	05	BEACH, REBECCA L. BIOLOGY DEPT HOLLINS COLLEGE ROANOKE, VA 24020	04
BARBER, MICHAEL B. 821 FLORIDA ST SALEM, VA 24153	16	BECK, EDITH P. 1405 LANDON COURT LYNCHBURG, VA 24503	14
BARFIELD, EUGENE B. 414 WASHINGTON AVE, SW ROANOKE, VA 24016	16	BECK, JAMES D. 1977 VESONDER RD PETERSBURG, VA 23805	05
BARKER, R. EDWARD JR. MAT SCI DEPT, THORNTON HALL UNIVERSITY OF VIRGINIA CHARLOTTESVILLE, VA 22903-2442	06	BEIDLEMAN, KATHARINE 3510 LOCHINVAR DR RICHMOND, VA 23235-1876	
BARNES, DENNIS W. 12 GILDERSLEEVE RD CHARLOTTESVILLE, VA 22903	05	BELL, HAROLD M. 708 CIRCLE DR BLACKSBURG, VA 24060	05
BARRA, ROSEMARY BIOLOGICAL SCIENCES DEPT MARY WASHINGTON COLLEGE FREDERICKSBURG, VA 22401	09	BELL, CHARLES E. JR. CHEMISTRY DEPT OLD DOMINION UNIVERSITY NORFOLK, VA 23508	05
BASKETT, RUSSELL C. 3150 JORDANS JOURNEY CT MECHANICSVILLE, VA 23111	04		

BENFIELD, E. F. BIOLOGY DEPT VPI & SU BLACKSBURG, VA 24061	04	BLANTON, DENNIS B. COLLEGE OF WILLIAM & MARY WILLIAMSBURG, VA 23185
BENTLEY, MICHAEL L. 1311 ASHLAND AVE EVANSTON, IL 60201-4039	11	BLATT, ELIZABETH 1831 GLENCOVE LANE RICHMOND, VA 23225
BENTZ, EDWARD J. JR. 7915 RICHFIELD RD SPRINGFIELD, VA 22153	15	BLISS, D. CRANDALL 322 SUMPTER ST LYNCHBURG, VA 24503
BERG, JOSEPH W. 3319 DAUPHINE DR FALLS CHURCH, VA 22042	01	BOARD, JOHN A. PO BOX 980034 RICHMOND, VA 23298-0034
BERG, LILLIAN D. 3319 DAUPHINE DR FALLS CHURCH, VA 22042	05	BOATMAN, SANDRA 1947 LAUREL MTN DR SALEM, VA 24153
BERQUEST, ROBERT A. 167 COVENTRY RD VIRGINIA BEACH, VA 23462	10	BOGESS, ROBERT K. CHEMISTRY DEPT RADFORD UNIVERSITY RADFORD, VA 24142
BETTENHAUSEN, LEE H. 12 CHADWICK CIR APT E NASHUA, NH 03062	07	BOOTH, SUSAN 2210 EXECUTIVE DR SUITE D HAMPTON, VA 23666
BEVAN, DAVID R. DEPT OF BIOCHEMISTRY & NUTRI- TION VPI & SU BLACKSBURG, VA 24061	09	BORKEY, PATRICIA D. 6331 CHAMBERLAYNE AVE MECHANICSVILLE, VA 23111
BHARDWAJ, HARBANS AGRI RESEARCH STATION BOX 9152 VIRGINIA STATE UNIVERSITY PETERSBURG, VA 23806	01	BOUSQUET, WOODWARD S. 17 E LEICESTER ST WINCHESTER, VA 22601-4613
BINNS, STEPHEN J. VDACS SEED LABORATORY 1 N 14TH ST, RM 238 RICHMOND, VA 23219	14	BOWERS, BONNIE B. PSYCHOLOGY DEPT HOLLINS COLLEGE ROANOKE, VA 24020
BIRCHARD, GEOFFREY F. BIOLOGY DEPT GEORGE MASON UNIVERSITY FAIRFAX, VA 22030	04	BOWMAN, RICHARD L. PHYSICS DEPT BRIDGEWATER COLLEGE BRIDGEWATER, VA 22812
BISHOP, JOHN W. BIOLOGY DEPT UNIVERSITY OF RICHMOND, VA 23173	15	BOYD, JAMES N. 4634 BUTTE RD RICHMOND, VA 23235
BLAIR, CARVEL HALL 250 PANTOPS MT RD BOX 37 CHARLOTTESVILLE, VA 22901-8680	15	BOYD, CLIFF SOCIOLOGY/ANTHROPOLOGY DEPT RADFORD UNIVERSITY RADFORD, VA 24142

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BOYD, DONNA SOCIOLGY/ANTHROPOLOGY DEPT RADFORD UNIVERSITY RADFORD, VA 24142	16	BRUBAKER, KENTON K. EASTERN MENNONITE COLLEGE HARRISONBURG, VA 22801	01
BRADIE, BRIAN CNU, 50 SHOE LANE NEWPORT NEWS, VA 23606-2998	02	BUDKE, EARL JR 1500 CONCORD APT #1 COLONIAL HEIGHTS, VA 23834	08
BRADLEY, TED BIOLOGY DEPT GEORGE MASON UNIVERSITY FAIRFAX, VA 22030	14	BUIKEMA, ARTHUR L. BIOLOGY DEPT VPI & SU BLACKSBURG, VA 24061	04
BRADLEY, ERIC L. BIOLOGY DEPT COLLEGE OF WILLIAM & MARY WILLIAMSBURG, VA 23185	04	BULL, ALICE LOUISE PO BOX 9633 HOLLINS COLLEGE ROANOKE, VA 24020-1633	04
BRAUN, WARREN L. 680 NEW YORK AVE HARRISONBURG, VA 22801	07	BULMER, WALTER ANNANDALE CAMPUS NORTHERN VIRGINIA COMM COLL ANNANDALE, VA 22003	
BRECKENRIDGE, CURT MT VERNON LADIES' ASSOC MT VERNON, VA 22121	16	BUMP, CHARLES M. HAMPTON IUNIVERSITY CHEMISTRY DEPT HAMPTON, VA 23668	05
BREIL, DAVID A. NATURAL SCIENCE DEPT LONGWOOD COLLEGE FARMVILLE, VA 23909	14	BUONCRISTIANI, A. MARTIN CHRISTOPHER NEWPORT UNIV 50 SHOE LANE NEWPORT NEWS, VA 23606	02
BRENIZER, JACK S. JR NUC ENG & ENG PHYSICS DEPT UNIVERSITY OF VIRGINIA CHARLOTTESVILLE, VA 22901	07	BURKHART, HAROLD E. FORESTRY DEPT VPI & SU BLACKSBURG, VA 24061-0324	01
BROWN, DAVID A. 6133 MERRIFIELD DR RICHMOND, VA 23225	05	BUSH, LANCE NASA Langley Research Center M.S. 200 HAMPTON, VA 23681-0001	13
BROWN, GARY L. DEPT BIOLOGICAL SCIENCES MARY WASHINGTON COLLEGE 1301 COLLEGE AVE FREDERICKSBURG, VA 22401-5358	04	BUSS, GLENN R. CSES DEPT VPI & SU BLACKSBURG, VA 24061	01
BROWN, BONNIE L. 5709 RIDGE POINT CT MIDLOTHIAN, VA 23112	01	BYLES, RICHARD A. 3115 CAMPUS BLVD NE ALBUQUEQUE, NM 87106-2108	
BROWN, MARLEY R. III ARCH RESEARCH DEPT COLONIAL WILLIAMSBURG FDN PO BOX 1776 WILLIAMSBURG, VA 23187-1776	16	BYRD, JAMES E. 44 SANDRA DR NEWPORT NEWS, VA 23602	07

CAIRNS, JOHN JR.	04	CHECK, WILLIAM D.	04
PO BOX 10661		9 BRAEMAR DR	
BLACKSBURG, VA 24062-0661		HAMPTON, VA 23669	
CALJOUW, CAREN	14	CHEENEY, RICHARD W. JR.	04
RT 1, BOX 40		50 SHOE LANE	
ROCKVILLE, VA 23146		CHRISTOPHER NEWPORT UNIVERSITY	
CALLE, LUZ MARINA	05	NEWPORT NEWS, VA 23606	
CHEMISTRY DEPT			
RANDOLPH-MACON WOMAN'S COL-			
LEGE			
LYNCHBURG, VA 24503			
CAMPBELL, F. HOWARD III	08	CHEVALIER, ROBERT L.	09
GEOLOGY DEPT		UNIVERSITY OF VIRGINIA -	
JAMES MADISON UNIVERSITY		PEDIATRICS	
HARRISONBURG, VA 22807		BOX 386	
CARLSON, ROSEANN J.	08	CHARLOTTESVILLE, VA 22908	
GEOLOGY DEPT			
TIDEWATER COMMUNITY COLLEGE			
1700 COLLEGE CRESCENT			
VIRGINIA BEACH, VA 23456			
CARSON, KEITH A.	09	CHINNICI, JOSEPH P.	04
BIOLOGICAL SCIENCES DEPT		BIOLOGY DEPT	
OLD DOMINION UNIVERSITY		VIRGINIA COMMONWEALTH	
NORFOLK, VA 23529-0266		UNIVERSITY	
CASTAGNOLI, NEAL JR	05	RICHMOND, VA 23284	
CHEMISTRY DEPT			
3103 HAHN HALL			
VPI & SU			
BLACKSBURG, VA 24061-0212			
CATON, RANDALL	02	CHLEBOWSKI, JAN F.	04
50 SHOE LANE		PO BOX 980614	
CHRISTOPHER NEWPORT UNIVER-		RICHMOND, VA 23298-0614	
SITY			
NEWPORT NEWS, VA 23606			
CAZIER, PENELOPE W.	14	CHRISTIE, GAIL E.	09
108 BONITO DR		PO BOX 980678	
GRAFTON, VA 23692		RICHMOND, VA 23298-0678	
CHALGREEN, STEVE D.	03	CHU, SUNG-CHI	17
BIOLOGY DEPT		COMPUTER SCIENCE DEPT, BOX 6933	
RADFORD UNIVERSITY		RADFORD UNIVERSITY	
RADFORD, VA 24142		RADFORD, VA 24142	
CHAMBERS, BARBARA F.	02	CLARK, KENNEDY H.	19
4220 DANRIDGE TERRACE		1500 E MAIN ST, SUITE 312	
ALEXANDRIA, VA 22309-2807		RICHMOND, VA 23219	
CHATTIN, AMY C.	04	CLARK, ALLEN K.	05
743 BRANDON AVE SW		CHEMISTRY DEPT	
ROANOKE, VA 24015-5023		OLD DOMINION UNIVERSITY	
		NORFOLK, VA 23508	
		CLARKE, ALEX M.	09
		PO BOX 250	
		WARSAW, VA 22572	
		CLOUGH, STUART C.	05
		125 FAIRWOOD DR	
		RICHMOND, VA 23235	
		COBLE, JAMES F.	08
		1357 PINE CONE CIR #201	
		VIRGINIA BEACH, VA 23456	
		COLEMAN, PHILLIP H.	03
		PO BOX 980549	
		RICHMOND, VA 23298-0549	

REGULAR MEMBERS

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COLLINS, PETER L. PO BOX 1344 FALLS CHURCH, VA 22041-0344	02	CRISSMAN, JUDITH A. CHEMISTRY DEPT MARY WASHINGTON COLLEGE FREDERICKSBURG, VA 22401	05
CONWAY, CAROLYN M. BIOLOGY DEPT, BOX 842012 VIRGINIA COMMONWEALTH UNIVERSITY RICHMOND, VA 23284-2012	04	CRITTENDEN, JOHN B. 1876 AZALEA DR BLACKSBURG, VA 24060	
CONWAY, ARTHUR F. BIOLOGY DEPT RANDOLPH-MACON COLLEGE ASHLAND, VA 23005	04	CROSS, GERALD H. 100 CHEATHAM VPI & SU BLACKSBURG, VA 24061-0321	04
COOK, DESMOND C. PHYSICS DEPT OLD DOMINION UNIVERSITY NORFOLK, VA 23529	02	CROUSE, WALTER C. COLLEGE AVE, DEPT NATURAL SCIENCES CLINCH VALLEY COLLEGE WISE, VA 24293	05
COOK, CHRISTOPHER JOHN 130 CASTLEGATE RD MACON, GA 31210-2151	05	CURLEY, JAMES W. LONGWOOD COLLEGE FARMVILLE, VA 23901	02
COOK, GREG TIDEWATER COMMUNITY COLLEGE 7000 COLLEGE DR PORTSMOUTH, VA 23703	17	DALEY, LAWRENCE R. COMPUTER SCIENCE DEPT HAMPTON UNIVERSITY HAMPTON, VA 23668	17
CORLEY, KARL C. JR. PO BOX 980551 RICHMOND, VA 23298-0551	10	DAMAJ, MOHAMAD IMAD PO BOX 980613 RICHMOND, VA 23298-0613	
COSTA, ALLEN J. COLLEGE OF SCIENCES CE/PS OLD DOMINION UNIVERSITY 1015 W 47TH ST NORFOLK, VA 23529-0276	01	DARCANGELIS, RITA COMPUTER SCIENCE DEPT MARY WASHINGTON COLLEGE FREDERICKSBURG, VA 22401-5358	17
COSTER, ABRAHAM A. 3541 W. BRADDOCK RD ALEXANDRIA, VA 22302	06	DAVENPORT, JAMES M. MATH SCIENCES DEPT VIRGINIA COMMONWEALTH UNIVERSITY RICHMOND, VA 23284-2014	12
COTHRON, JULIA H. 9293 BUTTERNUT LANE MECHANICSVILLE, VA 23111	11	DAVIES, KEITH M. CHEMISTRY DEPT GEORGE MASON UNIVERSITY FAIRFAX, VA 22030	05
COX, WILLIAM E. 1903 SHELOR LANE BLACKSBURG, VA 24061	15	DAY, ERIC R. ENTOMOLOGY DEPT VPI & SU BLACKSBURG, VA 24061-0319	19
CRANFORD, JACK A. BIOLOGY DEPT VPI & SU BLACKSBURG, VA 24061	04	DAY, DONAL B. UNIVERSITY OF VIRGINIA CHARLOTTESVILLE, VA 22901	02
CRAWFORD, EDWARD A. PO BOX 184 - 7076 JUANA DR MILLINGTON, TN 38053	04		

DE SA', RAFAEL O. BIOLOGY DEPT UNIVERSITY OF RICHMOND RICHMOND, VA 23173	04	DUDASH, MICHELE R. BOTANY DEPT UNIVERSITY OF MARYLAND COLLEGE PARK, MD 20742-5815	14
DEAVER, BASCOM S. JR. PHYSICS DEPT UNIVERSITY OF VIRGINIA CHARLOTTESVILLE, VA 22904	02	DUFFY, DEBRA L.F. 1527 LEAVIEW AVE NORFOLK, VA 23503	08
DEMENTI, PATRICIA L. 7519 OAKMONT DR RICHMOND, VA 23228	04	DUKAT, MALGORZATA PO BOX 980540 RICHMOND, VA 23298-0540	05
DERRINGER, DANIEL R. CHEMISTRY DEPT HOLLINS COLLEGE ROANOKE, VA 24020	05	DUNCAN, PERRY M. PSYCHOLOGY DEPT OLD DOMINION UNIVERSITY NORFOLK, VA 23508	10
DESJARDINS, STEVEN G. CHEMISTRY DEPT WASHINGTON & LEE UNIVERSITY LEXINGTON, VA 24450	05	DUPUY, DAVID L. PHYSICS DEPT VIRGINIA MILITARY INSTITUTE LEXINGTON, VA 24450	02
DEVINCENTIS, JOSEPH G. 109 APPLEWHITE ST SMITHFIELD, VA 23430-5922	05	DURRILL, PRESTON L. 1309 MADISON ST RADFORD, VA 24141	05
DEWEY, WILLIAM L. PO BOX 980568 RICHMOND, VA 23298-0568	09	EBEL, RICHARD BIOCHEMISTRY & NUTRITION DEPT VPI & SU BLACKSBURG, VA 24061	09
DEWOLFE, THOMAS E. BOX 133 HAMPTON SYDNEY, VA 23943	10	ECKERLIN, RALPH 8333 LITTLE RIVER TURNPIKE ANNANDALE, VA 22003	04
DIECCHIO, RICHARD J. GEOGRAPHY & EARTH SYS SCIENCE DEPT GEORGE MASON UNIVERSITY FAIRFAX, VA 22030	08	EDELMAN, LEONARD BIOLOGY DEPT LYNCHBURG COLLEGE LYNCHBURG, VA 24501-3199	03
DOMINEY, RAYMOND N. CHEMISTRY DEPT UNIVERSITY OF RICHMOND, VA 23173	05	EDMONDS, WILLIAM J. 1610 KENNEDY AVE BLACKSBURG, VA 24060	01
DOUGLAS, RUTH A. RT 6, BOX 1 CHARLOTTESVILLE, VA 22902	11	EDWARDS, CAROLYN 1990 OLD HANOVER ROAD SANDSTON, VA 23150	09
DUBERG, JOHN E. 4 MUSEUM DRIVE NEWPORT NEWS, VA 23601	02	EDWARDS, LESLIE E. 1990 OLD HANOVER ROAD SANDSTON, VA 23150	09
DUDAS, FRANK O. GEOLOGY DEPT 113A TECHNOLOGY BLDG OLD DOMINION UNIVERSITY NORFOLK, VA 23529	08	EGLOFF, KEITH T. 124 JORDANS JOURNEY WILLIAMSBURG, VA 23185	16

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GANDOUR, RICHARD D. CHEMISTRY DEPT, 107 DAVIDSON HALL VPI & SU BLACKSBURG, VA 24061-0212	05	GLOVER-FISCHER, DEBORAH P. 3901 GLOUCESTER RD ROCKY MOUNT, NC 27803-1112	05
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RADFORD, VA 24141-3902			
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23173			
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BLACKSBURG, VA 24061-0237		BRIDGEWATER, VA 22812	
HOBBS, MARY C.		HILL, TREVOR B.	05
6296 KENNEDY COURT		228 LONGHILL RD	
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HILU, KHIDIR W.			
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VPI & SU			
BLACKSBURG, VA 24061			
HINKELMANN, KLAUS			
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HUDLICKY, MILOS 1005 HIGHLAND CIRCLE BLACKSBURG, VA 24060	05	JOHNSON, W. REED 115 FALCON DR CHARLOTTESVILLE, VA 22901	07
HUFFORD, TERRY L. BIOLOGICAL SCIENCES DEPT 2023 G STREET NW GEORGE WASHINGTON UNIVERSITY WASHINGTON, DC 20052	14	JOHNSON, DAVID M. LIFE SCIENCE DIVISION FERRUM COLLEGE FERRUM, VA 24088	05
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HUSTON, CLIFTON A. P.O. BOX 198 LIGHTFOOT, VA 23099	16		

JOHNSON, MICHAEL F. 2842 FRANKLIN WALK FALLSCHURCH, VA 22042	16	KEPPEL, CYNTHIA PHYSICS DEPT HAMPTON UNIVERSITY HAMPTON, VA 23668	02
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JONES, W. GEORGE 1554 WOODCREST HTS DANVILLE, VA 24541	10	KING, BRUCE L. BIOLOGY DEPT RANDOLPH-MACON COLLEGE ASHLAND, VA 23005	14
JONES, JOAN H. 1810 POPLAR GREEN DR RICHMOND, VA 23233	11	KING, H. E. PSYCHOLOGY DEPT WASHINGTON & LEE UNIVERSITY LEXINGTON, VA 24450	10
JONES, ERIC N. BIOLOGY DEPT MARY BALDWIN COLLEGE STAUNTON, VA 24401	14	KING, BERTHA C. 10308 WALTHAM DR RICHMOND, VA 23233	11
JONES, BETTY WADE 1746 WESTOVER AVE PETERSBURG, VA 23805	11	KINSLEY, CRAIG 116 RICHMOND HALL UNIVERSITY OF RICHMOND, VA 23173	10
KAROWE, DAVID BIOLOGY DEPT, BOX 842012 RICHMOND, VA 23284-2012	04	KIRBY, RAYMOND H. 925 QUEEN ELIZABETH DR VIRGINIA BEACH, VA 23452	10
KAUMA, SCOTT WILLIAM PO BOX 980034 RICHMOND, VA 23298-0034	09	KIZER, FRANKLIN D. RT 2, BOX 1449 LANCASTER, VA 22503	11
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LEE, LARRY D. MATH & STATISTICS DEPT OLD DOMINION UNIVERSITY NORFOLK, VA 23529-0077	12	LINEBAUGH, DONALD W. POB 8795 COLLEGE OF WILLIAM & MARY WILLIAMSBURG, VA 23187	16
LEE, H.M. PO BOX 980057 RICHMOND, VA 23298-0057	09	LISS, IVAN B. BOX 6941 RADFORD UNIVERSITY RADFORD, VA 24142	17
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LEUNG, WING H. BOX 6422 HAMPTON UNIVERSITY HAMPTON, VA 23668	05	LUE, LOUIS PING-SION 3003 TINSBERRY DR COLONIAL HEIGHTS, VA 23834	01
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LEWIS, LYNN O. BIOLOGY DEPT MARY WASHINGTON COLLEGE FREDERICKSBURG, VA 22401	03	LUQUIRE, KAREN B. 7817 ANTIOPPI ST ANNANDALE, VA 22003	04
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MARING, LISE D. 49 RIVERMONT DR NEWPORT NEWS, VA 23601	04	MCAVOY, TOM J. ENTOMOLOGY DEPT VPI & SU BLACKSBURG, VA 24111	19
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MARSHALL, MARYAN L. 5804 NAVAJO CIRCLE LYNCHBURG, VA 24502-1412	05	MCGOVERN, JAMES J. 2109 ADELBERT RD CLEVELAND, OH 44106	09
MARTIN, BILLY R. PO BOX 980613 RICHMOND, VA 23298-0613	09	MCKEE, CURTIS S. BOX 6946 RADFORD UNIVERSITY RADFORD, VA 24142	10
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		CHARLOTTESVILLE, VA 22903	
MENGAK, MICHAEL T.	04	MINNIX, R. B.	02
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WHEELER, ALFRED G. PA DEPT OF AGRICULTURE 2301 NORTH CAMERON ST HARRISBURG, PA 17110-9408	01	WIGGLESWORTH, HAYWOOD A. 2420 POATES DR RICHMOND, VA 23228-3042
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GRIMSHAW, AMY H. 3855 OCEAN TIDES DR VIRGINIA BEACH, VA 23455	10	HAYES, BRYAN 1301 LONGWOOD DR #1 NORFOLK, VA 23508	10
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HALECKI, JANICE 9629 HAMMETT PKWY NOFORLK, VA 23503	10	HECKMAN, JOHN R. 1020 DERRING HALL VPI & SU BLACKSBURG, VA 24061	04
HALLORAN, REBECCA 12815 TWUN BROOK PKWY #209 ROCKWOOD, MD 20852	04	HEIGES, KELLY 12359 SWEETBOUGH CT NORTH POTOMAC, MD 20878	10
HANSEN, RONDA K. 1338 WINDMILL POINT CRES VIRGINIA BEACH, VA 23454-4760	09	HELPFERT, PETER A. 1309 WERTLAND ST APT D10 CHARLOTTESVILLE, VA 22903-2871	
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HARDEN, HOLLY 1108 H JOYCE LEE CIRCLE HAMPTON, VA 23666	04	HENLEY, WILLIAM F. 100 CHEATHAM HALL VPI & SU BLACKSBURG, V 24061-0321	19
HARPOLE, DOUGLAS N. DEPT FISHERIES & WILDLIFE SCI VPI & SU BLACKSBURG, VA 24061	19	HERMAN, JULIE PO BOX 598 GLOUCESTER POINT, VA 23062	08
HARRIS, SANDRA 10279 LAKE RIDGE SQUARE CT #H ASHLAND, VA 23005-8130	04	HIGGS, REBECCA D. 28 COUNTRYMENS CT CHARLOTTE, NC 28210-7475	03

HILL, STEWART A. BIOLOGY DEPT VPI & SU BLACKSBURG, VA 24061	04	KIFLE, YESHIRAREG 157 HICKORY DR SW PAPASKALA, OH 43062-9105	03
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